THE GLASS INDUSTRY
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OBEAR-NESTER ADDS A NEW FACTORY

FOR many years the plant of the Obear-Nester Glass Co., at East St. Louis, Ill., has consisted of two separate factories: one having a furnace melting amber glass for five machines, and one melting flint glass for nine bottle machines. The demands for the products of this company have increased rapidly, with the result that in July, 1935, it was found necessary to add to the productive capacity of the plant by the construction of a complete new factory.

The new factory, designed and constructed by the Amsler-Morton Co., under the supervision of Joseph Early, is equipped with a melting furnace for six machines, thereby increasing the total number of machines in the plant from 14 to 20 and adding 43 per cent to Obear-Nester's productive capacity.

The new factory adjoins the old plant, making it possible to utilize the existing facilities of water, gas, power and sewers. The property is served by two railroad sidings: one at the north end for delivery of raw materials and, one at the south end for shipping the finished ware.

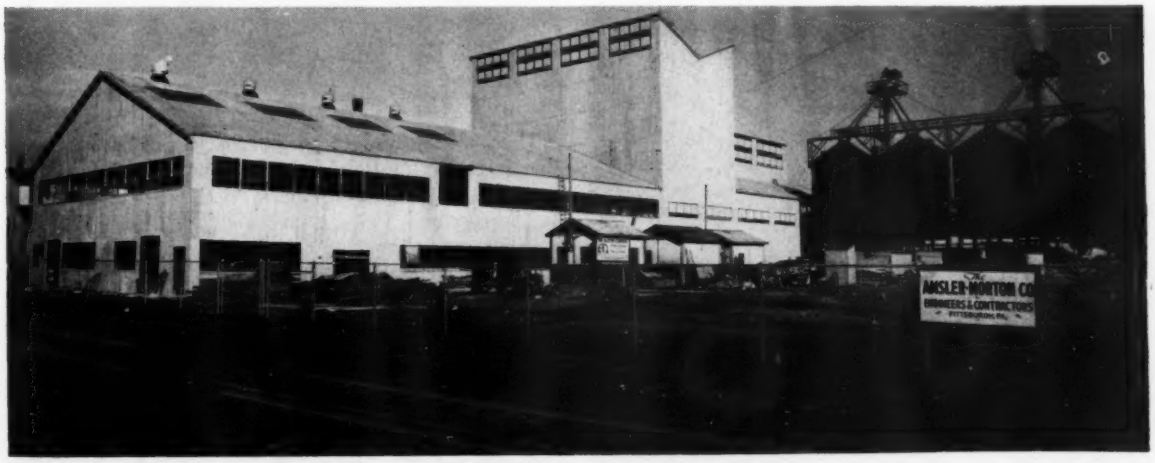
Although the new building, which is 80 feet wide by 250 feet long, has a single common floor, it should be considered as three separate buildings for each section is designed to perform a specific function of a modern automatic bottle factory. The construction is steel with a heavy copper bearing galvanized sheet steel covering, and glazed steel-ventilating type sash.

The section of the building housing the furnace is 80 feet wide and 77 feet long and has a basement under its entire area. The trusses, which have an 80 foot span, are 28 feet above the factory floor. The roof has a large continuous ventilator 40 feet wide with a "V" profile, rather than the usual shape. This design develops streamline flow of the heated air and gases out of the building through the continuous, mechanically operated hinged doors at the top of the ventilator to control the factory temperature. Vertically pivoted doors are provided at ground level to control the circulation of outside air for cooling the building.

A radically new type of glass factory machine building, 80 feet wide and 40 feet long, adjoins the furnace building. The roof trusses are 60 feet above the factory floor level and at right angles to the trusses in the other buildings. They are of the same design as the furnace building trusses to give maximum control of ventilation. The height of the roof forms a ventilating shaft over the machines to create a strong controllable natural draft and provide the operators with the best possible working conditions. This building is also designed for an electric crane for handling machinery.

Adjoining the machine building is the lehr and packing room building which is 80 feet wide and 134 feet long. Its south end has a mezzanine floor 80 feet long with an area of 6,400 square feet. The trusses in this building have a clearance of 26 feet with a conventional roof. The mezzanine floor is 12 feet above the factory floor. Four 30-inch diameter roof ventilators are provided in this building. Over the mezzanine floor there are eight, 8 by 12 foot, corrugated wire glass skylights. The carton fabricating equipment is located on the mezzanine floor, and space is provided for the storage of carton stock.

Bottle making being a continuous operation, artificial lighting is provided in the furnace building by four 500 watt lamps supported on each roof truss. Each



General view of plant showing batch storage and mixing room.

Top, Inside of batch plant with mixer at the rear; below, rear of tank and batch feeder with batch bucket in place.

lamp is mounted with a reflector of special design, having a diffusing glass shade, which may be easily removed and cleaned, and a non-tarnish aluminum reflector and cover. Thirteen 1,000 watt lamps with similar reflectors have been spaced around the machine building, to minimize shadows and assure ample light for the machine operators. The lehr building is lighted by four 500 watt lamps on each roof truss in the furnace building. The mezzanine floor and the sorting room under it have five 300 watt lamps on each truss. In addition to these there are two 500 watt lamps over the end of each lehr to enable sorters to properly inspect the ware.

The Obear-Nester Glass Company operates its own power plant producing direct current at 230 volts for all requirements. Power is brought to the new factory by a four cable line. There are power distribution switchboards in the furnace building for the batch handling equipment and in the machine building for the glass feeders, bottle machines, lehr loaders, and lehrs.

Batch Storage and Handling System

It is now possible for the Obear-Nester Glass Co. plant to make 250 tons of glass per day. At this rate, about 290 tons of raw materials and crushed cullet must be unloaded from railroad cars, stored, proportioned, mixed, transported, and fed into the furnaces every 24 hours.

To perform these operations manually would require not less than 490 man-hours of labor per day. At 40 cents per hour, the cost of this labor (not counting supervision, turn-over, training, and other overhead) figures about 70 cents per ton of batch delivered to the melting furnace. Further, with manual handling, it is practically impossible to deliver batch to melting furnaces in a correctly proportioned and properly mixed condition. This results in increased cost per gross of bottles packed due to unnecessary wastage.

The largest single units of the batch plant are the elevated steel bins for storing raw materials and crushed cullet. These bins are on steel columns, located along the railroad siding at the north end of the property, east of the furnace building. The bottoms of the bins are self-cleaning and located about 14 feet above the mixing floor level. The space under the bins is enclosed with corrugated galvanized steel and ventilated glazed steel sash—all attached to the bin columns—to form the mixer room connecting directly into the furnace building at the western end. These bins have a total storage capacity of about 1,700 tons and, by means of vertical partitions, provide for about 780 tons of sand, 350 tons of crushed flint and amber cullet, 250 tons of soda ash, 150 tons of lime, 90 tons of feldspar, and 80 tons of borax. Ladders, both inside and outside, manholes, and walkways give access to all working parts of the bins.

Raw materials are unloaded from railroad cars by means of power shovels and delivered to the storage bins by two vertical belt and bucket elevators designed especially for this installation. Carefully constructed distributing heads on the elevators direct the materials into the proper bins.

Foreign cullet is received in a steel hopper either from railroad cars or automotive trucks, and is fed from the hopper to a cullet washer, then through a crusher and deposited on an inclined belt conveyor which passes it over a magnetic pulley to remove iron. It is delivered to the west elevator for distribution to the storage bin. Factory cullet also is delivered to a steel hopper, then direct to the crusher without washing. The rejected bottles — "Off-ware" from the lehrs — are gathered in hand trucks. The quenched cullet, collected in water tubs in the basement under the machines, is elevated to the hopper by an electric hoist.

Thus, all materials, with the exception of a few minor chemicals that must be handled manually are stored overhead in the bins. Each bin is equipped with a weighing hopper and a dial type scale for proportioning the batch, arranged so that each material may be weighed separately and accurately. There is an electrically driven travelling batch mixer operating on a track under the bins to gather the weighed materials from the weighing hoppers, and mix them. The operator of the mixer rides the machine and performs all the operations necessary to proportion, gather and mix the batch. Each batch consists of about 50 cubic feet of raw materials and crushed cullet weighing about 4,500 pounds. As each batch is mixed, the operator moves the mixer

and discharges it into a 50 cubic foot mixed batch bucket in the basement. This bucket stands on a turntable which is electrically driven and automatically controlled. As it turns, it brings the loaded batch bucket under an opening in the furnace room floor through which the bucket is lifted, and returns empty to the mixer. The handling of the mixed batch in the furnace room in these buckets is the duty of a second operator. When the bucket of mixed batch is lifted to the factory floor from the basement, it is transported by a travelling electric hoist, either to a place on the factory floor for future use, or direct to the mechanical batch feeder.

The metal line of the new furnace is 100 inches above the factory floor, and the batch feeder is placed on a structural steel platform about six feet above the floor, with suitable steps at both sides. The operator places the mixed batch bucket on a stand above the batch feeder and opens a gate on the bottom of the bucket to permit the feeder to draw the mixed batch down out of the bucket and deliver it to the melting furnace. The operator then returns the empty bucket to the turntable.

The turntable drive is arranged so that each time the operator pushes the control button the table makes one-quarter of a revolution and automatically stops, placing an empty bucket under the mixer and a loaded bucket under the hoist. Enough buckets are provided to store mixed batch for the night shift.

The operating schedule is planned so that 16 hours mixing will provide mixed batch for 24 hours operation. Future increases of production, therefore, can be met merely by providing men to operate the equipment the remaining 8 hours, up to a maximum of 270 tons of glass per day.

In comparison with the usual manual cost of 70 cents per ton, this batch system will deliver mixed batch to the melting furnace for about 25 cents per ton including depreciation, interest on invested capital, maintenance, power, and labor. It may be noted in passing that the 45 cents per ton differential, on a 200 ton daily basis, would amount to $90 per day, or about $27,000 per year—or two to four cents per gross of bottles.

The Melting Furnace

The melting furnace is a cross fired regenerative tank, having a melting hearth, 18 x 38 feet, to supply glass to six automatic bottle machines. It is designed with four ports on each side, and is fired with natural gas from the Louisiana gas field. Electrocast blocks were used in the doghouse and the throat.

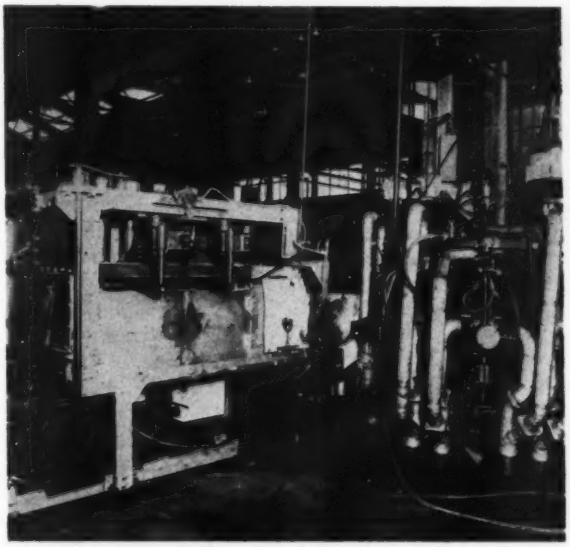
The steel binding for the furnace was designed and fabricated to provide ample but flexible support for the refractories. A walkway around the top of the buckstays provides easy access for adjusting the tie-rods during the heating-up period. Walkways also are provided at the rear of the ports and between the ports so that the burners may be reached conveniently for necessary adjustments and replacement. A third walkway under the ports provides means for inspecting the tank blocks, and a convenient place to work when hot repairs become necessary.

The checkers are of ample width and sufficient depth to produce maximum preheat temperature and exert suitable pressure upon the air to develop the highest melting rates. They are entirely above basement floor level and are connected by an accessible flue to the stack which is located in the northwest corner of the furnace building, thereby leaving usable floor space unobstructed.

The air reversing valve is of new design, with the reversing mechanism mounted on a vertical shaft carried in ball bearings. This valve permits a separate adjustment of air to the two checkers and reduces draft loss to a minimum. The stack damper is enclosed in an iron hood to prevent leakage at this point.

The steel and concrete reenforced furnace chimney is 4 feet 6 inches inside diameter and 125 feet high. It is lined with fire brick throughout and is protected from lightning by four points through two copper leads to a plate buried in the ground.

The furnace is equipped with a recording pyrometer to maintain a history of operating conditions. The couples are located between the first and second ports, between the fourth port and the bridgewall, in the nose



Above, the Amco lehr loader; below, lehrs and machine end of tanks.

of the refining end, in the sidewall of each checker chamber, and in the flue near the stack. The couples in the regenerators are used to check temperature swing, to control reversing periods and to avoid melting down the checker brick.

A differential draft gauge with an inlet on each side of the stack damper indicates stack conditions and enables the operator to maintain the desired draught.

Natural gas enters the factory under high pressure and is reduced to operating pressure by a regulator at the north end of the building. The furnace lines extend from this point over the ports on each side of the furnace and leads are taken down to the individual burners. There is also another service line carried from this point around to the nose end of the furnace where it is used for the feeders and lehrs. A continuous record is kept of the pressure. This chart also shows the time of every reversal of regenerators and provides a secondary check of the operation.

The Feeders and Machines

There are six eight-mold automatic bottle machines in use and the six feeders delivering glass to these machines are equally spaced around the semi-circular end of the furnace, to distribute the load on the working end of the tank.

The pneumatic hot glass feeders can be regulated to feed the proper weight of bogs for a great variety of bottles and maintain uniform temperature conditions. The high furnace metal level above the machines was provided to obtain the full benefit of gravity to fill the neck rings by impact, thereby insuring an uniform full finish on the bottles. This drop also enables the machines to be operated to a higher speed, as it is not necessary to extend the "blow down" time to insure perfect finishes.

Compressed air for the operation of the machines is brought from the central power house in a 12-inch line. The air passes through a separator to remove oil and moisture and through a pressure regulator which reduces the pressure from 60 to 40 pounds before it enters a large receiver. From the receiver, the air is conducted around the front of the furnace. There is also a smaller line around the nose to supply air to the burners on the glass feeders. A third line is run into the factory to provide air for general utility purposes.

The air system for cooling the bottle machines delivers the air from beneath the floor. This plan is thermally correct, because air obtained from below the point of use, is at the lowest possible atmospheric temperature when delivered to the molds. Placing of the piping beneath the machines also makes possible a complete survey of the operation at a glance.

The cooling fan house is located at basement level, east of the machine building. A large duct runs from the fan through the basement to a header from which leads are taken to the various machines. Each machine lead has a blast gate for control. The wind is carried through the floor in streamlined ducts and is distributed first to 6-inch pipes and then through 4-inch pipes to the various mold stations. There is also an air washer for use during the summer months, to reduce the temperature of the air about 20 degrees.

The machines, when producing 90 tons of bottles per day, concentrate, together with the furnace and lehrs, about 15 per cent of the total heat used in the process in a small area and a tall chimney type building of new design is provided as part of the cooling system to eliminate the continuous operation of unnecessary fans in summer.

The Lehr Loaders

After the bottles have been formed on the machines, the takeout sets them on short conveyors to be carried directly into lehr loaders which transfer them automatically to the lehr conveyors. This automatic mechanical loading reduces the cost per bottle not only by eliminating labor but also by improving the annealing and increases the usual percentage of commercial ware approximately five per cent. The bottles do not touch each other.

These loaders are designed to handle many different sizes and shapes of bottles, and operate with a very simple movement of a carrier arm with a suitable adjustable stabilizer for tall or narrow ware. The operation is automatically controlled by means of a photo-electric cell (electric eye) in such a manner that most problems formerly encountered in automatic loading of bottles are eliminated.

The lehr may be located as close as practical for the delivery of ware with the maximum sensible heat of melting. This feature provides for the vertical adjustment of the loader to the takeout level of the machine which it serves. Thus all ware is conveyed through the shortest horizontal path to the lehr instead of through a series of arcs, inclined planes or elevators.

The Lehrs

All the bottles are conveyed for annealing through three-foot wide newly designed lehrs, 85 feet long. They are the muffled type designed to operate on a minimum of natural gas or oil, and protect the bottles from all contamination from waste gases. The waste gases are mechanically moved through the lehr muffle and positive control of the temperature in all sections of the lehrs is possible regardless of weather conditions.

The lehrs are supported on rollers and may be moved from one position to another, should occasion arise. The new charging end design adapts them for use directly at the machine takeout, regardless of the length of the bottle. The rear ends of the lehrs are provided with cooling doors by which the temperature of the finished ware may be controlled for delivery to the sorters at temperatures convenient for handling.

Each lehr has an indicating pyrometer connected to six points along the conveyor, by which the temperature curve throughout the length of the lehr may be regulated. A draft gauge is also provided.

Carton Handling and Assembly

The mezzanine floor above the sorting and packing end of the lehr building is for the storage and fabrication of cartons. These are received knocked-down, in bundles, at the south end, from railroad cars or trucks. A belt conveyor elevates the bundles and delivers them to the mezzanine floor. Over the end of each lehr there is a combination chute and gravity conveyor arranged

Packing room under mezzanine, looking toward the tank.

to deliver fabricated empty cartons direct from the mezzanine floor to the sorters. This arrangement frees the south end of the factory floor of everything except filled cartons ready for shipment.

Distribution of the Finished Ware

After inspection and sorting, the flat top trucks loaded with filled cartons are ready for distribution. They may be delivered to motor trucks, to railroad cars on the siding at the south end of the building, or by a narrow gauge interplant railroad to one of the company warehouses where they may be reserved for future shipment.

The new Obear-Nester factory is an interesting illustration of the efficiency that can be obtained from the centralization of responsibility. In July 1935, the Amsler-Morton Company submitted complete designs, plans and specifications for the work, which included proposals covering all foundations and buildings, the radial brick chimney, the batch plant and equipment such as the regenerative melting furnace, lehr loaders, lehrs, and all accessories. Within the month, all were accepted and the work of clearing the site begun.

About the middle of August, excavations for the foundations and basement were started. Concrete work and building erection were scheduled so furnace construction could be started November 1st, and lehr construction, December 1st. The furnace was ready for fire December 10th and while it was being heated to operating temperature and filled, the lehrs, automatic bottle loaders, and other accessories were completed, batch materials and crushed cullet were placed in storage and the new factory was placed in operation the first week of January, 1936.

TRANSPARENT PLASTIC GLASS FOR AIRCRAFT WINDOWS

Although no organic plastic has yet been developed that possesses both the qualities and the low price of glass, nevertheless, such plastics are now serving as windows on many airplanes. The organic plastics are approximately one-half as heavy as glass, which is a distinct advantage for aeronautical purposes. Plastic materials can be made up in sheets which are flexible and can, therefore, be readily fitted into openings in curved surfaces. Such inclosures offer considerably less wind resistance than the faces ordinarily required when flat glass is used.

The flexible plastics now in use, however, lack the weathering and scratching resistance characteristic of glass. Recognizing that there is a real need for an improved flexible aircraft window material, the United States government, in cooperation with the National Advisory Committee for Aeronautics, is studying the suitability of transparent plastics for this purpose.

All commercially and experimentally available synthetic resins and cellulose derivatives will be examined to determine their transparency; resistance to surface abrasion, flexibility; impact strength at high and low temperatures, resistance to deterioration by heat, cold, and sunlight, and to the action of water, gasoline, soap, and similar materials; dimensional stability; flame resistance; and related properties.

FIBROUS GLASS AT 50 MILES A MINUTE

Statistics on fibrous glass that will stir the imaginations of glass men have recently been cited by U. E. Bowes, director of research for Owens-Illinois. Fibrous glass for textile purposes can be drawn at a rate of 50 miles a minute. It takes a worm several weeks to spin a mile of silk fibre, but molten glass may be drawn into smaller fibre and can equal the worm's yardage in three seconds. Of course, this operation is faster than the eye can see. The muzzle velocity of a Springfield army rifle bullet is about 52,000 feet per minute but glass fibre can be drawn at some 260,000 feet per minute. The glass fibre drawn this way weighs only 1½ pounds per cubic foot as contrasted to European glass fibre for insulation which weights some six pounds per cubic foot. Permission has been granted to certain European companies to use the American method.

TANK FURNACES

Le Four a Bassin, by R. W. Devillers and F. E. Vaerewyck. Monograph No. 1. Published by Les Etudes des Composes Siliceux, 34, Rue d'Arenberg, Brussels, Belgium.

There is not in the English language, so far as we know, any book specifically treating glass tanks. Trinks' book deals principally with steel furnaces and for the most part with furnaces having very little in common with glass tanks. Such treatment as the glass tank gets in our textbooks of glass technology is necessarily very far from complete and in most cases not very up-to-date. The published literature on the subject is fairly voluminous, but very scattered and distinctly contradictory. Admitting that the glass tank is an awkward and disgusting kind of engine, it remains a fact that a lot of money is spent on them every year, that they are designed empirically and often wrongly.

A book in French now appears, which we would like to review if we were equal to the task. It follows very promptly upon Dr. Partridge's book published in England, entitled "Refractory Blocks for Glass Tank Furnaces," which was reviewed in the January issue of The GLASS INDUSTRY. The two books scarcely meet at any point. The English book deals almost entirely with the chemistry and physical properties of the glass-containing flux blocks, while the French book is concerned almost entirely with the engineering end of things, the construction and operation of a glass tank. In some 230 pages, a wide range of matters is covered, of interest partly to the glass technologist, but particularly to the plant operator. Beginning with an outline history of the glass tank to date, and some of the glass melting devices that have been proposed and operated more or less successfully, though not as yet in general use, the discussion proceeds to a classification of the commoner types of tanks, the materials used in the construction thereof, and the fundamental factors involved in the several parts of the tank, and their arrangement.

An outline is given of methods of calculating the proportions of the different parts of the tank, and of the use of various materials of combustion and their advantages and limitations.

We proceed from this to the regime established in the tank, the processes of melting and refining and conditioning of the glass, the currents generated in the tank of thermal origin, and the heat balance of typical tanks.

The construction of the tank and the method of starting it into operation and letting it out are described as practiced in Belgium, and a discussion is given of control apparatus for measuring and regulating temperatures and pressures and so forth, in the tank.

The book is full of figures, both illustrations and arithmetic. Of the former, there are more than a hundred; and of the latter, apparently many thousands. The present reviewer has found the latter a little difficult to assimilate, as everything is expressed in the metric system and needs to be translated before it can be compared with American practice. One gets the impression, however, after the conversion has been made, in some cases, that American tanks are still a long way ahead of European tanks. Perhaps after all the figures have been translated into English units, that impression might not persist in its entirety.

So far as can be determined from a single, rather careful reading, the authors have chosen their subject wisely and dealt with it well. Their judgment on many matters seems to be very sound. We congratulate the publishers on bringing out this monograph, and wish that a comparable treatment were available in the English language.—F. W. P.

NEPHELINE SYENITE
A NEW BATCH MATERIAL

In Europe, especially in Germany and Russia, the use of igneous rocks as glass-making materials has been the subject of numerous investigations with the result that the use of such rocks as trachyte, phonolite, syenite, and others, as glass batch constituent is common practice in many glass plants. Much of the igneous rock is used as a feldspar substitute although, in Russia particularly, it has been used as the principal glass constituent; sand, lime, and a small amount of alkalies being added to decrease the alumina content of the resulting glass.

In this country, few experiments have been made on the use of aluminous rocks, other than feldspar, for glassmaking purposes. A recent announcement, however, by Canadian Nepheline, Ltd., indicates that a highly aluminous rock (nepheline syenite) will soon be available to glass manufacturers in the United States.

Nepheline syenite is an igneous rock consisting of orthoclase (monoclinic potash spar, K20, Al_2O_3, 6 SiO_2), nephelite (an orthosilicate of Na, K and Al, (Na K) Al_8 Si_9O_{34}) with one or more of the following minerals; hornblende, augite and biotite. The rock results from magmas especially rich in alkali and low in silica. Similar to granite, nepheline syenite occurs in stocks or batholiths along the axes of present or past mountain ranges, but differs from granite in the absence of free quartz.

The chemical composition of the rock being produced at present is approximately as follows:

Silica, 59.43%	Lime, 0.27%
Alumina, 24.52%	Magnesia, 0.02%
Gronoxide, 0.06%	Soda, 0.91%
Titania, 0.01%	Potash, 5.10%
Phosphorous, 0.02%	Ignition loss, 0.44%

Due to the high alumina and low iron content of this material, its use as a source of alumina in many types of glass seems very promising.

The deposit is situated at Blue Mountain in Methuen Township, Ontario, Canada. The grinding and concentration plant is located at Lakefield, Ontario, and at the present time is equipped to produce a granular, low iron nepheline syenite concentrate suitable for glass.

CHARLES J. B. SWINDELL DIES

With great regret, The GLASS INDUSTRY reports the death of Charles J. B. Swindell, president of Swindell Brothers, Inc., Baltimore, on Feb. 28. Mr. Swindell was well known in both the window and container branches of the industry. He joined the Swindell Company, which was organized by his father and older brothers, immediately upon his graduation from high school and became a member of the firm at 25 years of age. Upon the death of his brother, Walter B. Swindell, in 1934, he assumed the presidency.

A. C. S. ANNUAL CONVENTION

Many Papers of Interest to Members of the Glass Industry are Planned

THE annual meeting of the American Ceramic Society, to be held in Columbus, Ohio, March 29 to April 4, promises to be the largest in the history of the Society. A program, which includes papers on fundamental and practical ceramic and glass subjects, has been prepared to interest engineers, technologists and educators.

The program of the Glass Division will begin, very properly, with a tribute to the late Dr. Otto Schott, a pioneer of modern glass technology, long associated with optical and technical glass manufacture at Jena in Germany. Professor Silverman is eminently fitted for the presentation of this memorial because of his personal acquaintance with European glass technologists, and his deep interest in the history and literature of glass.

The report by Badger and Silverman on tensile strength is a continuation of work presented at the 1935 summer meeting. Another interesting paper on tensile strength is presented by Slayter of Owens-Illinois who advises that something like the theoretical strength that may be expected from glass (as prophesied by Preston) is realized when the glass fibers are exceedingly small. This paper is likely to indicate what may be expected of glass yarns and of glass as a textile fabric.

The Corning Laboratories bring in several scientific papers. Taylor and Smith continue the investigation of solubility by the powder method, and extend the work to cover glasses of widely different compositions. Strong presents some very accurate determinations of modulus of elasticity, especially as it is affected by heat treatment and temperature of the glass. Lillie has found a mathematical explanation for the rate of crystal growth as dependent upon liquidus temperature and known viscosity relations. He will show also, by means of motion pictures, the actual process of release of stress from glass during annealing. Littleton and Wetmore have added to our knowledge of the behavior of glass as an electrical conductor in the annealing zone and report that no transformation point can be observed when the glass has been previously stabilized.

Hettinger has at length come into the open with some of his remarkable toughened glass, and will discuss some special methods of testing goggles, other than wearing them in the face of shrapnel. Scholes has attempted to relate the abradability of glasses to their compositions by a method somewhat like a commercial grinding process.

From the physics laboratory of Purdue come two contributions by Lark-Horovitz and Ferguson, who have found a method for estimating the surface area for particles used in the solubility test, and have studied the lithium-sodium silicate glasses with reference to electrical conductivity and viscosity. Their work on the area of particles should be of special interest in connection with durability and its measurement.

Professor Watts of Ohio State is a newcomer on the glass division program, and our guess is that he is able to explain how to glaze a false tooth made from one of his porcelain bodies, in such a manner that the glaze will be lasting in the victim's mouth. Another first paper is by Wessels of Alfred, who summarizes his M.S. thesis on baryta as a substitute for dolomitic lime.

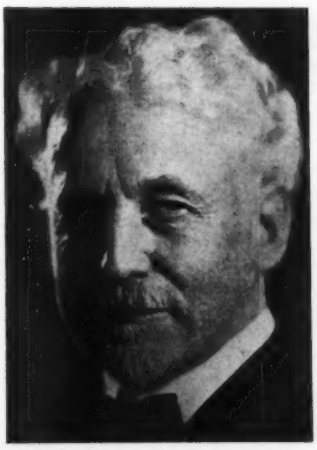
The Division is fortunate in having another paper by Dr. Warren of M.I.T., who is continuing his painstaking study of the X-ray patterns of glasses. It is perhaps worthy of comment that Dr. Warren's paper appears promptly, to meet the criticisms advanced in one of the recent German discussions on this subject. Preston, the polymath, steps out as a physical geographer and explains the currents in a glass tank by comparison with currents in some of the larger terrestrial cavities.

Finn and Glaze of the Bureau of Standards contribute a method for the estimation of the elusive boron oxide. Any improvement on the existing tedious and scarcely accurate methods for the determination of this element will certainly be most welcome. Peters and Knapp have made an intensive study of the problem of scratch hardness, approaching it as a corollary to the problem of cutting fine lines on glass plates. We hopefully look for some real numbers, giving a more quantitative expression to this matter of hardness than we have hitherto possessed.

The ceramic department at the University of Illinois is again represented, by Parmelee and Harmon, who have made a study of the surface tension of glasses containing alumina. All glassmakers who have had experience with the inordinate foaming of such glasses will be interested in learning the reason for it.

The third ceramic department represented on the program is Penn State, whose Professor Bair presents an X-ray study of lead oxide-silica glasses, finding confirmation of the work of Warren and Loring. He has also made an interesting correlation of physical properties of glass with atomic arrangement, which seems to corroborate the findings of the X-ray study.

The program thus covers a variety of subjects. Each subject is specifically treated, and each paper is based upon laboratory data. The entire list of papers reflects credit upon the soliciting ability of Joe Gregorius, as well as upon the activity of the individual members of the Glass Division in fact finding.



Ross C. Purdy, secretary of the A.C.S. who has recently been elected an honorary member of the Czechoslovak Ceramic Society.

Program of Sessions of American Ceramic Society's Annual Meeting

Saturday—Meeting of Board of Trustees.

Sunday, 10:30 A.M.—Committee Meetings.
12:30 P.M.—Joint luncheon, Trustees and committees.
3:00 P.M.—Association of Ceramic Educators.
5:00—7:30 P.M.—Joint dinner, Trustees and committees.
8:30 P.M.—President's reception.

Monday, 10:00—12:30 A.M.—General Sessions.
2:00—5:00 P.M.—Ceramic Ware Firing; Business Meeting of Fellows.
6:30 P.M.—Get Acquainted Pep Supper.
9:00 P.M.—Student reception.

Tuesday, 9:30—12:00 A.M.—Division Meetings.
5:45 P.M.—Ceramic school reunions.
8:30 P.M.—Edward Orton, Jr., Fellowship Lecture by Dr. William J. McCaughey of Ohio State University. Presentation of Charles Fergus Binns Medal.
9:30 P.M.—Concert by Ohio State University Glee Club Quartette and String Ensemble.

Wednesday, 9:30 A.M.—Division Meetings.
6:00 P.M.—Keramos Dinner.
9:30 P.M.—Dance and floor show.

Thursday, 9:30 A.M.—Enamel division meeting.
9:30 A.M.—Brick engineers meeting.
2:00 P.M.—Structural Clay Products Research Foundation.
2:00 P.M.—Visits to various points of interest.

Friday and Saturday—Plant visits.

Columbus itself, being in the heart of the ceramic manufacturing world, will add considerably to the interest and importance of the meeting. In or nearby, are manufacturers of china ware, stoneware, floor tile, drain tile, sewer pipe, paving and building brick, electrical porcelain, refractories, vitreous enameled ware and glassware. Also located in Columbus are several nationally known educational and research institutions, such as Ohio State University, Edward Orton, Jr., Ceramic Foundation, and the Battelle Memorial Institute. This makes possible many visits to plants as well as to points of interest in the history of American ceramics and glass.

It was at Ohio State University that Edward Orton, Jr., founded the first ceramic school, which through the years has gained a national reputation as an educational and research organization of the first rank under the directorship of A. S. Watts. Also located on the Ohio State campus is the Ceramic Art Department under the direction of G. A. Bole. Through its studies of various ceramic problems, many lasting and important contributions have been given to science.

The Edward Orton, Jr., Ceramic Foundation, producers of standard pyrometric cones for measuring heat treatment in ceramic kilns, maintains a research staff to study pyrometric cones, heat treatments and allied subjects.

Battelle Memorial Institute is one of the best equipped research laboratories in the country and its projects embrace many fields, including metallurgy, chemistry, fuels and ceramics.

In addition to the serious business of the meeting, there will be considerable in the way of entertainment. A dance with a floor show will be held on the night of April 1, and at various other times glee clubs, quartettes and orchestras will entertain. An interesting series of lectures and entertainments are also being planned for the ladies.

The Glass Division will hold its technical sessions in the ballroom of the Neil House, Tuesday and Wednesday, March 31 and April 1, with Chairman Urban E. Bowes of Owens-Illinois Glass Co. presiding. Vice-Chairman Joseph S. Gregorius of Pittsburgh Plate Glass Co. has prepared a program of 18 papers, whose titles and sources indicate a high order of interest and importance.

In addition to the technical papers formerly scheduled, the Division will probably hear further reports from the committee on durability tests. Some action will also be taken concerning the participation of the Division in the International Congress of Glass Technologists in England, July, 1936.

Representation of the Glass Division on the official staff of the American Ceramic Society will be further augmented by the election of Francis C. Flint, Chief Chemist of the Hazel-Atlas Glass Company, to the Presidency of the Society. Mr. Flint is the sole nominee for this office for the coming year.

Glass Division Papers.

1. Otto Schott: A Tribute

By Dr. Alexander Silverman, Department of Chemistry, University of Pittsburgh, Pittsburgh, Pa.

2. Progress Report on the Determination of the Tensile Strength of Glass

By A. E. Badger and W. B. Silverman, Department of Ceramic Engineering, University of Illinois, Urbana.

A brief description of the apparatus used to determine the tensile strength of glass fibers is presented with results for some typical glass compositions.

3. The Modulus of Elasticity of Glass
(a) The Effect of Thermal History
(b) The Effect of Temperature Change

By Guy E. Stong, Corning Glass Works Laboratory, Corning, N. Y.

An apparatus for determining the Modulus of Elasticity of glass samples is described. The probable error of the determinations is computed to be plus or minus 0.2 per cent, the observed precision being plus or minus 0.05 per cent. Work showing the effect of previous thermal history on the Modulus of Elasticity at room temperature and the effect of elevated temperatures on the Modulus of Elasticity of samples having different thermal histories is reported.

4. Experience in the Impact Tests of Super-Tough or Heat Treated Glass

By E. L. Hettinger, Willson Products Inc., Reading, Pa.

The various difficulties of present methods of testing for specific purposes will be explained. The vibration breaking point of glass will be shown by samples of glass projected upon the screen. Reference will be made to kinematics of stress.

5. Strength and Physical Properties of Fine Glass Fibers and Yarns

By James Slayter, Owens-Illinois Glass Co., Toledo, O.

Glass fibers have been produced in large quantities running from .0007" to .00005" fiber diameter. The strength of individual fibers and the strength of yarns produced from these fibers have received preliminary investigation. Some of the strengths obtained are quite remarkable, running into the order of one and one-half million pounds per square inch. Even these strengths fall short of theoretical possibilities. Some possible reasons and explanations are discussed.

6. The Abrasion of Glasses as Related to Composition

By S. R. Scholes, New York State College of Ceramics, Alfred University, Alfred, N. Y.

Loaded glass rods are held in a thick metal disc rotating above a rotating steel plate fed with wet flint as an abrasive. Fused silica rods are ground with each run as a standard. Loss by abrasion, corrected for load and diameter, is reported for a number of compositions.

7. Solubility Characteristics of Glasses Basically Different in Composition

By W. C. Taylor and R. D. Smith, Corning Glass Works Laboratory, Corning, N. Y.

Comparative results are given using the A.C.S. No. 1 Powder Method on several glasses representing lime, lead, and borosilicate compositions. The effect of temperature on rate of attack and some comparison of surface attack as compared to the powder method are given.

8. The Area of Glass Particles as Used in Durability Tests

By J. E. Ferguson and K. Lark-Horovitz, Physics Department, Purdue University, Lafayette, Ind.

Commercial bottle glass, Pyrex-brand glass, and a lead glass were crushed as prescribed for durability tests. The shape and size of the particles were determined microscopically, and the gross surface was determined from the relation between density, specific surface, S, and particle size, r, as:

$$S = C \cdot \frac{1}{rd}$$

Where d=density of glass.

C=a constant depending on shape of particle.

The surface was determined using an adsorption method developed by one of the authors (Phys. Rev., 29, 617 (1927), which employs oleic acid as adsorptive. The surface calculated, assuming a monomolecular layer of oleic acid on the glass surface, is comparable for the different glasses but is only a small fraction of the total surface available. This agrees with results obtained by other investigators on the distribution of dyes on glass surfaces.

9. Some Preliminary Observations on Reactions Between Glass and Phosphate Solutions

By Prof. A. S. Watts, Ceramic Engineering Department, and Prof. J. B. Brown, Physiological Chemistry Department, Ohio State University, Columbus, O.

An unusual reaction observed in some tests of glasses for chemical solubility.

10. Devitrification Rates as Governed by Viscosity

By H. E. Lillie, Corning Glass Works Laboratory, Corning.

A simple expression for devitrification rate (relative to a maximum rate) as a function of temperature is derived from a consideration of free energy changes. With the liquidus temperature and the viscosity relations known, relative rates of crystal growth may be computed which agree very well with those observed by Dietzel. At present no attempt is made to predict absolute rates.

11. Effects of Replacing Dolomitic Lime by Baryta Upon Some Properties of Glass

By Vincent E. Wessels, New York State College of Ceramics, Alfred University, Alfred, N. Y.

The effect of replacing dolomitic lime, both in weight percentage and molecularly, by baryta upon the chemical durability, softening temperature, coefficient of linear expansion, density, index of refraction, elasticity, and several other properties was studied. Discussions of the methods, apparatus, and results are included.

12. Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3

By B. E. Warren, Massachusetts Institute of Technology, Cambridge, Mass.

The X-ray scattering curves for vitreous SiO_2 and B_2O_3 are obtained in a vacuum camera, using monochromated Mo and Cu radiation. A Fourier analysis of the scattering curve gives directly a curve representing the distribution of neighboring atoms about any one atom. For SiO_2 the distribution curve establishes definitely the tetrahedral silicon-oxygen network. The distribution curve for B_2O_3 indicates a triangular coordination, each boron surrounded by three oxygens, and each oxygen, shared between two borons. For both materials the inter-atomic distances come out in excellent agreement with the results of previous crystalline investigations. The importance of the new Fourier method of analysis of glass diffraction patterns is emphasized by the fact that the distribution curves which are obtained are unique, no assumptions as to structure being involved.

13. Motion Picture Analysis of Annealing

By H. E. Lillie, Corning Glass Works Laboratory, Corning.

By means of motion pictures, the complete strain pattern in a sample can be observed at definite intervals during annealing, subsequent analysis being thereby facilitated. The present work deals with relative stress release rates observed at different depths in the glass. Motion pictures of the annealing process at various temperatures are shown.

14. Electrical Conductivity and Viscosity for Lithium Sodium Silicate Glasses

By E. Lark-Horovitz and J. E. Ferguson, Department of Physics, Purdue University, Lafayette, Ind.

Measurements of electrical conductivity and viscosity were carried out similar to those reported before for soda and soda potassium silicate glasses. The effect of substituting lithium for potassium is discussed, taking into account the differences in ionic size and mobility.

15. The Electrical Conductivity of Glass in the Annealing Zone as a Function of Time and Temperature

By J. T. Littleton and Warren A. Wetmore, Corning Glass Works Laboratory, Corning, N. Y.

It is shown by measurements on samples of glasses having a varied degree of heat treatment that the electrical conductivity of glasses undergoes a stabilization process at constant temperature and that this rate of stabilization is a function of the viscosity of the glass. The resistance of the stabilized glass varies linearly with 1/T where T is the absolute temperature and no change in slope of this curve is observed. In other words, there is no transformation point observable when all measurements are made on stabilized glass.

16. Circulation of Glass in Tanks

By F. W. Preston, Butler, Pa.

The circulation of glass in an ordinary tank is compared by analogy with the circulation of water in the Mediterranean and Black Seas and with the flow of lava in Kilauea Crater. It is argued that the shape of the flux line erosion shows that two factors are active, one essentially chemical and the other physical. This is shown by analogy with the canyons of the West, and the V-shaped valleys of the East. Some parts of the subject seem susceptible to mathematical treatment and an effort is made so to treat them.

17. An Application of Henry's Law to the Routine Determination of Boron in Glass

By Francis W. Glaze and A. N. Finn, National Bureau of Standards, Washington, D. C.

A method for the routine determination of boric oxide in glass, based on Henry's law, has been developed. It depends upon the "partition" of boric acid between water and ether in the presence of hydrochloric acid and ethanol. A slightly acid solution of the fusion of the glass is shaken with ether and ethanol, and the boric acid in the ether layer titrated. The "partition coefficient" is 0.406. Barium, fluorine and zinc interfere to some extent. The advantages of this method are its speed and simplicity without material sacrifice of accuracy.

18. The Cutting of Fine Lines in Glass

By C. G. Peters and Frederick Knoop, National Bureau of Standards, Washington, D. C.

In attempts to rule fine lines in glass for the production of

W. J. McCaughey of Ohio State University is the Edward Orton, Jr., Fellowship lecturer.

transparent line standards, it was found that the glass shattered, leaving irregular lines. After considerable experience with ground diamond points, we have succeeded in ruling fine, straight-edged lines in glass. It was thought that this method might be used to ascertain the relative hardness or relative resistivity to scratching of different glasses. For this work, it was necessary to produce suitable ground diamond tools and to investigate the cutting angles, adjustment and wear of the diamond points. Measurements were made on a number of different glasses to determine the widths of the lines produced by a given adjustment and load of the point. Measurements were also made to determine the load required to produce shattering under a given adjustment of the tool.

19. The Effects of Aluminum on the Surface Tension of Molten Glass

By C. W. Parmelee and C. G. Harmon, Department of Ceramic Engineering, University of Illinois, Urbana, Ill.

The maximum bubble pressure method has been used to determine the surface tensions of molten glasses. The compositions of the glasses were those typical of certain types of commercial products. The article contains a brief summary of the theory and application of the method. The surface tensions of the glasses studied were of the order of 300 dynes per centimeter and the temperature coefficients were 0.017 dynes per centimeter per degree centigrade. It was found that Al_2O_3 raised the surface tension of soda-lime-silica glass, the increase being linear between 2 per cent Al_2O_3 and 8 per cent Al_2O_3, but apparently not linear below 2 per cent Al_2O_3.

20. The Constitution of Lead Oxide-Silica Glasses

By George J. Bair, Asst. Prof. of Ceramics, Pennsylvania State College, State College, Pa.

The Atomic Arrangement—An X-ray investigation of a series of lead oxide-silica glasses gives further evidence of a continuous random, three-dimensional network of atoms for the structure of glass. The structure of lead oxide-silica glasses is similar to that obtained for soda-silica glasses by Warren and Loring.

The Correlation of the Physical Properties With the Atomic Arrangement—Various physical properties of a series of lead oxide-silica glasses were determined. The variations of these properties with composition and temperature are explained on the basis of a continuous, random, three-dimensional, network structure. Justification of Adams' and Williamson's equation for the rate of strain release in a glass is obtained by assuming that the flow of a glass fiber in the annealing range is a combination of an elastic stretch and a true viscous flow of a glass of constant viscosity.

Refractories Division Papers

"The Use of Penetrating Radiations in the Measurement of the Porosity of Refractories," by J. B. Austin; "A New Method for Testing the Corrosion Resistance of Refractories to Phosphate Slag," by G. R. Pole; "A New Method for Studying the Flow Characteristics of Glasses and Slags at Elevated Temperatures," by E. P. Barrett and J. A. Taylor; "Flow of Ceramic Bodies at Elevated Temperatures," by F. H. Norton; "Refractories in Metallurgical Industries," by John D. Sullivan and Clyde E. Williams; "Report of the Research Committee: 'Objectives Without Cash,'" by Donald W. Ross; "A Comparison of the Thermal Expansion of Used Silica Brick from an Insulated and Uninsulated Basic Open-Hearth Roof," by R. H. H. Pierce, Jr. and J. B. Austin; "The Total Emission of Radiation from Refractories at High Temperatures," by J. L. Finck; "Young's Modulus of Elasticity and Strength of Refractories in Tension," by R. A. Heindl and L. E. Mong; "Note on the Appearance of Quartz as a Devitrification Product of Vitreous Silica," by L. J. Trostel; "Introduction to the Symposium on Production of Dense Aggregates," by Nelson W. Taylor; "Grinding and Crushing; the Laws of Crushing of Solids," by Lincoln T. Work; "Some New Viewpoints on Crushing," by R. S. Dean; "Screening and Blending for High Density," by F. O. Anderegg; "Particle Packing and Particle Shape," by H. E. White and S. F. Walton; "Tempering and Forming by Dry Pressing for High Density," by C. M. Dodd; "Spinel Refractories from Magnesite and Diaspore," by C. R. Amberg; "Large Special Shapes Made of Insulating Refractory Mixtures," by E. J. Bognar.

COMPENDIUM OF EUROPEAN GLASS

The 1936 edition of AGENDA, for Glass, Ceramic, Enamel, and Cement Plants, By Jacques Wolf. Published by L'Edition Universelle at Brussels, Belgium.

This is the third edition of Agenda which, as its name implies, consists in part of a diary for the year 1936, allowing space for notes of business appointments, conventions, and so forth. In addition, it contains such miscellaneous information as: calendar for the year, notes of holidays and religious festivals in the important glass-producing countries, and extensive lists of firms supplying raw materials and so forth, mostly in Continental Europe but to some extent in England also; a list of tables converting English measure into French, and the comparison of foreign moneys with Belgian and French francs; physical and chemical data are given on many materials of interest to glass workers and ceramists, and analyses are quoted of clays, dolomites, feldspars and so forth obtained from many European sources.

There is a brief chapter devoted to the mechanical working of glass, with special references to glass bottles and hollow ware. This chapter is not illustrated and gives very little information of immediate consequence to American workers. It may, however, have some historical interest. There are other short chapters devoted to cement working and so forth.

While this little work is of interest more particularly to European readers, and especially to readers in France and Belgium, we are glad to receive a copy of it, and to notice in this and in other recent works in the French language, a drift away from the pure empiricism and "art" of earlier days towards a technology and science in glass making.—F. W. P.

CORNING ADDS TO PLANT

A large three-story building to house the storage, shipping and box-making departments of the Corning Glass Works, Corning, N. Y., is reported to be under construction. This building which will be constructed chiefly of glass blocks, steel and concrete will adjoin the main plant of the company. Each of the three floors will have an area in excess of 30,000 square feet and will add considerably to the plant, although there will be no increase in production activities. An entirely new manufacturing plant for the Fibre Products Division is also being erected at this time.

NEW CUSTOM HOUSE GUIDE ISSUED

The 1936 Edition of the Custom House Guide has recently been published in New York and embodies approximately 60,000 changes in tariff regulations since the 1935 edition was published. Due to the recent nine reciprocal trade agreements entered into by the government, some 482 commodities from 83 countries have been affected.

EFFECT OF ALUMINA ON THE SOFTENING TEMPERATURE AND VISCOSITY OF GLASS

By C. W. PARMELEE AND A. E. BADGER*

A series of glasses consisting of 17.4 *per cent* Na_2O, 10.1 *per cent* CaO, 72.5 *per cent* $(SiO_2 + Al_2O_3)$, *with* Al_2O_3 *ranging from* 0 *to* 10 *per cent, was prepared by melting in platinum crucibles. The softening temperatures of these glasses were measured by an interferometric method. The softening temperatures may be represented by the straight line equation,* $t = 582 + 3.2p$, *where* t *is the softening temperature in* °C *and* p *is the percentage of* Al_2O_3 *in the glass. A correlation between softening temperature and viscosity was made on the basis of Twyman's Law of viscosity changes in the annealing range. From the latter standpoint, the viscosities of the glasses at any constant temperature, where Twyman's Law holds, may be represented by the relation* $V_p = V_o\ (1.28)^p$, *where* V_p *is the viscosity of the base glass and* p *is the percentage of alumina.*

GLASSES do not have exact melting points but pass gradually from the rigid state to that of a viscous liquid as the temperature of the glass is raised. However, this transition is sufficiently definite so that the term "softening temperature" may be applied justifiably to denote the temperature at which appreciable flow occurs in the glass.

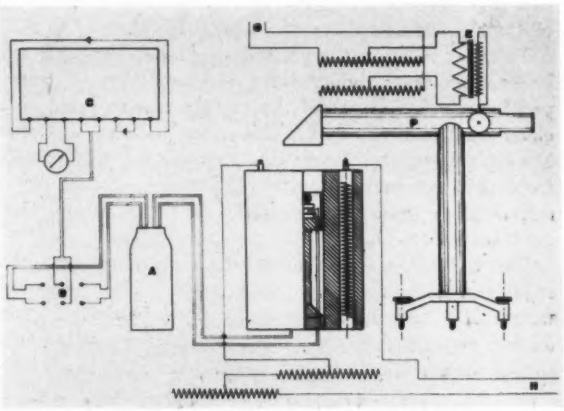
The softening temperature will depend upon the method of measurement, higher values usually resulting from the cruder methods. The size of the glass test piece, the specific heat and thermal conductivity of the glass, as well as other physical properties, will affect the determination. Therefore, the more exact measurements should be expressed in terms of viscosity.

Several methods of measuring softening temperatures have been used in the past.[1] For the measurements given in this publication, a modification[2] was used of the Fizeau-Pulfrich interferometric method as developed for the determination of the thermal expansions of materials. By means of this apparatus[3], the changes in softening temperatures of a series of glasses which contained progressively increasing amounts of alumina were obtained.

The glass to be tested is ground into the shape of three small regular pyramids with an altitude of about 3 mm. These pyramids of glass are adjusted to nearly equal altitudes and are then placed between two plane-polished disks of fused quartz (*B* in Figure 1), which are enclosed in an electric furnace. The fused quartz disks are illuminated with light from a helium discharge tube *E*, which passes through a right-angle prism in the telescope *P*. The system of interference fringes produced at *B* is viewed through the eyepiece of the telescope *P*.

The temperature of the glass pyramids is measured by two chromel-alumel thermocouples which are placed at a distance of about 1 mm. from two of the pieces. This distance is made small in order that the temperatures of the glass samples be essentially the same as that indicated by the thermocouples. It was found that the difference in the temperature indications of the two thermocouples was negligible. The thermocouples lead to an ice-water mixture contained in the thermos bottle at *A* and thence to a switch *D* and a potentiometer *C*. Figure 2 is a photograph of apparatus used in the laboratory.

In making a determination, the temperature of the glass samples is raised slowly by adjusting the power input to the furnace at *H*. As the temperature rises, the glass specimens expand and a parade of interference fringes passes across the field of view of the telescope. When the softening temperature of the glass is reached, the interference fringes reverse their direction of passage. In practice, this softening temperature may be checked within ±2°C. (*Continued on next page*)



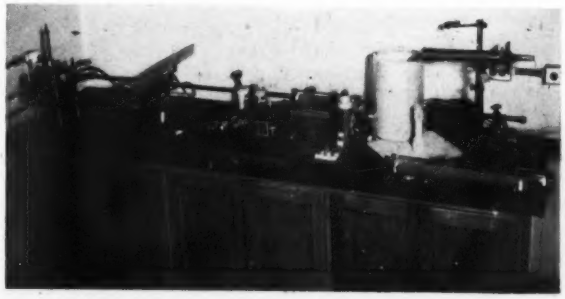


Fig. 1 above and Fig. 2 below.

* Published with permission of the Engineering Experiment Station, University of Illinois.

[1] J. W. Mellor, A. Latimer, A. D. Holdcroft: "The Softening Temperatures of Lead: Silica Glasses," Trans. Ceram. Soc. (England) 9, 126 (1909-10).

[2] The apparatus was assembled by J. J. Theodore. The measurements were made with the assistance of W. C. Pittman and R. C. Taylor.

[3] The following publications may be consulted for more complete descriptions of interferometers:
G. E. Merritt: "Application of the Interferometer to Measurements of the Thermal Dilatation of Ceramic Materials," Bur. of Standards Sci. Paper No. 485 (1924).
L. D. Fetterolf, C. W. Parmelee: "The Effects of Sodium Barium, and Zinc Oxides on Elasticity and Thermal Expansion Coefficients of Glass," J. Am. Ceram. Soc. 12, 193, (1929).
G. E. Merritt: "Interference Method of Measuring Thermal Expansion," Bur. of Standards, Jour. Research 10, 59 (1933).

This apparatus determines the softening temperature of small glass pyramids which are under a load equal to the weight of the upper fused quartz interference plate (about 7 grams). The softening temperatures of any glasses so tested correspond to the viscosities which permit deformation under such a load in a given time interval. Therefore, the apparatus provides a means of comparing the viscosities of glasses in their softening intervals.

The base glass chosen lies in the field of compositions of some important commercial glasses. From this composition, a series of glasses was made in which Al_2O_3 was substituted for SiO_2 in steps of 1 per cent and extending up to 10 per cent Al_2O_3. This series of glass compositions may be expressed as the following: 17.4 per cent Na_2O, 10.1 per cent CaO, 72.5 per cent (SiO_2 + Al_2O_3). The base glass is equivalent on a molecular percentage basis to 1.4 Na_2O : 0.9 CaO : 6.0 SiO_2.

The compositions of the glasses with their corresponding softening temperatures are listed in Table I.

Table I
Composition of Glasses

Na_2O (%)	CaO (%)	SiO_2 (%)	Al_2O_3 (%)	Softening Temperature °C
17.4	10.1	72.5	0	580
17.4	10.1	71.5	1	586
17.4	10.1	70.5	2	591
17.4	10.1	69.5	3	589
17.4	10.1	68.5	4	593
17.4	10.1	67.5	5	601
17.4	10.1	66.5	6	604
17.4	10.1	65.5	7	605
17.4	10.1	64.5	8	608
17.4	10.1	63.5	9	610
17.4	10.1	62.5	10	616

About 100 grams of each glass batch were prepared by weighing on a chemical balance the proper amounts of c.p. materials. Melting was made in platinum crucibles at a temperature of about 1350°C.

In order to make the glass more homogeneous, it was broken out from the crucible and ground to a coarse powder which was mixed thoroughly and replaced in a clean platinum crucible. This glass powder was then heated, as described, until the enclosed bubbles escaped from the surface of the melt. Samples of this twice-melted glass were used to determine the softening temperature.

The difficulties of making up a glass to any prescribed composition are very great. The losses in weight of a glass batch are due to the evolution of gases during the melting reactions, the driving off of absorbed moisture, selective volatilization of the batch constituents, and dusting. Small amounts of impurities in even chemically pure substances complicate the problem of obtaining the exact chemical composition desired. However, if proper precautions are taken, the melted glass will approach very closely to the desired composition.

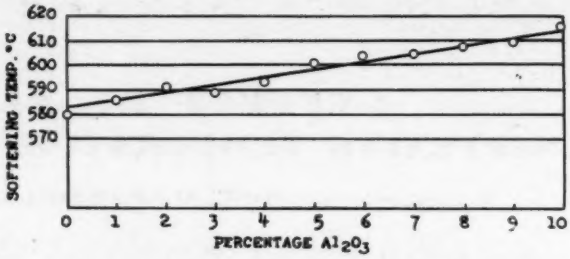


Fig. 3. The effect of Al_2O_3 on the softening temperature of glasses.

The chemical compositions listed in Table I are computed from the glass batches. Although they do not represent actual analyses of the melted glasses, the error is negligible in this case.

The softening temperatures of the series of glasses as determined by the interferometric method described are listed in Table I. Figure 3 represents the results graphically and shows the effect of substituting Al_2O_3 for SiO_2 in the base glass (17.4% Na_2O, 10.1% CaO, 72.5% SiO_2).

Within experimental error, the results may be represented by the straight line equation,

$$t = 582 + 3.2\ p, \qquad (1)$$

where t is the softening temperature in °C and p is the percentage of alumina substituted for silica.

The increase in viscosity of glass near its softening point, which is produced by the substitution of alumina for silica in the glass composition, may be deduced from these results with the aid of Twyman's Law,[4] which states that the mobility, M, of a glass in the annealing range is

$$M = k\ 2^{-t/s}, \qquad (2)$$

where k is a constant depending on the glass composition and t is the temperature in degrees Centigrade. In the following treatment, the revised equation,

$$M = k\ 2^{-t/9}, \qquad (3)$$

will be used since English[5] found that the latter equation was generally in better agreement with experimental results.

Since viscosity is inversely proportional to the mobility M of Twyman's Law, it follows from equations (1) and (3) that the viscosities of the glass at any constant temperature, where Twyman's Law holds, increase as alumina is substituted for silica in accordance with the following equation,

$$V_p = V_o\ (1.28)^p,$$

where V_p is the viscosity of any glass of the above series V_o the viscosity of the base glass, and p is the percentage of alumina[6].

The New York State College of Ceramics at Alfred University will hold its fourth annual ceramic festival, March 19 and 20 in honor of St. Patrick, patron saint of engineers. At this time the Ceramic College will be in full operation and there will be an exhibit of industrial ceramic ware as well as a comedy parade and a ball.

[4] F. Twyman: "The Annealing of Glass," J. Soc. Glass Tech., Trans. 1, 61 (1917).

[5] S. English: "The Effect of Various Constituents on the Viscosity of Glass near its Annealing Temperature," J. Soc. Glass Tech., Trans. 7, 25 (1923).

[6] Other references are as follows:

S. English, W. E. S. Turner: 'The Effect of Aluminum on the Annealing Temperature of Glass," J. Soc. Glass Tech., Trans. 5, 115, (1921).

V. Dimbleby, F. W. Hodkin, W. E. S. Turner: 'The Influence of Aluminum on the Properties of Glass," J. Soc. Glass Tech., Trans. 5, 107 (1921).

V. Dimbleby, S. English, F. W. Hodkin, W. E. S. Turner: "Further Investigations of the Influence of Alumina on the Properties of Glass." J. Soc. Glass Tech., Trans. 8, 173 (1924).

S. English: "The Effect of Composition on the Viscosity of Glass," J. Soc. Glass Tech., Trans. 7, 25 (1923); 8, 205 (1924); 9, 83 (1925); 10, 52 (1926).

H. R. Lillie: "Viscosity of Glass Between Strain Point and Melting Temperature," J. Am. Ceram. Soc. 14, 502 (1931).

H. R. Lillie: "Precise Measurements of the Viscosities of Glasses near their Annealing Points," J. Am. Ceram. Soc. 15, 418 (1932).

G. Gehlhoff, M. Thomas: Article in "Lehrbuch der Technischen Physik," p. 342, by G. Gehlhoff (Barth, Leipzig, 1932).

H. R. Lillie: "Viscosity-Time-Temperature Relations in Glass at Annealing Temperatures," J. Am. Ceram. Soc. 16, 619 (1933).

GERMAN SYMPOSIUM ON GLASS TECHNOLOGY

WE ARE indebted to Dr. Maurach, Secretary of the German Society of Glass Technology, for complete abstracts of the papers presented at the January Conference in Berlin. We present those which are of general technical interest.

Dependence of the Surface Area of Glass Powder on the Method of Pulverizing and Sieving; Also Its Measurement by Optical Procedure, *By Dr. E. Berger, Jena.*

In every estimation of chemical attack by the powder method, the surface area of the powder is concerned. Since a powder consists of an unimaginable variety of grains of different size and shape, we are obliged to use a statistical procedure for the calculation of surface area, which was described in an earlier paper.

For powders "expressed in equal volumes," the surface area is calculated by the equation:

$$O = f_\omega \frac{\log l_2/l_1}{l_1 - l_2} \quad \text{and approximates:} \quad \frac{f_\omega}{l_m}$$

in which l_2, l_1, and l_m are the open mesh diameters of the two sieves and respectively their mean, and f_ω is an approximate constant, the so-called surface-form factor. From this relationship, it follows that O possesses the same percentage of uncertainty as the open mesh diameter.

The equation may be applied only for "ideal sieves," that is, those which have always equal mesh sizes, and for complete separation of the single fractions. These conditions are only approximately realized in practice. We studied, therefore, by microscopic measurement, the probability of the error in the mesh diameters of 19 test sieves of different fineness, and found the Gaussian law of probability of error holding. It was therefore decided to characterize the test sieves by two numbers, the mean mesh diameter and the mean variation from the mean.

The technique of sieving also thoroughly established the dependence of the sifted-out mass on the time of sifting, the open mesh diameter, the quantity of material sifted, etc., and that it could be calculated from quite simple theoretical considerations. The uncertainty of the superficial area, so far as this arises from the sieving, could easily be reduced below 2 per cent.

The manner of pulverizing is very important in the preparation of powder. Upon the first crushing of the lumps of glass in the mortar, there arises a preponderance of laminated fragments. If these are thoroughly stirred about before the subsequent grinding, the grains become successively more rounded. The larger the grains are, the more rapidly this process continues. It is followed up by the estimation of the mean weight of the grains and their surface silhouette.

The silhouette of a given powder can be measured with a certainty of about 5 per cent by a special photo-electric process. Observation in different orientations to the beam of light gives a definite measure for the variation of the grains from spherical form (anisotropic factor). Eventually these measurements enable us to derive the absolute extent of the "smooth" surface, that is, of the surface without reference to re-entrant or concave broken surfaces.

The values obtained from a great number of powders showed a good constant value for the mean "smooth" surface. This establishes a minimum limiting value. The surface areas obtained from previous measurements of solubility in acid for different glasses are 1.3 times higher than this limit. Consequently, there is a considerable increase of the surface area not only for unetched, but in several cases also, for powders treated with acids and alkalis which cause exceedingly small surface irregularities.

The testing methods hitherto used are not shown in sufficient amount for the estimation of this true surface attack. The clarification of this problem is of fundamental importance for every powder method of testing and should be studied in further researches.

Glass in Modern Construction, *By Dr. J. Polivka, Prague.*

Modern architecture can not satisfy itself with the formerly accepted properties of windows: namely, light and ventilation. Today's requirements of glass in construction are: (1) Heat insulation for economic heating, and the air-conditioning thereby made possible. (2) Sound-proofing. (3) Refraction of daylight and its equal distribution in space. (4) Selection of light with regard to suitability for greater efficiency. (6) Supporting members of glass. (7) The resistance of large glass plates.

Each of these problems opens important fields of research. It will be demonstrated how the solution of separate problems has thus far been attained, and in what direction they should be pursued further. By means of test results and procedures, the properties of a new glass are described which offers good protection against heat and sound, protects against bright light and disperses daylight completely and conducts it into the farthest part of a room. The question of "sweating" of a window receives special attention and it is shown how this can be prevented.

Also investigated are certain properties of pressed glass which is intended for carrying members (glaseisenbeton). On the basis of experiment and trial, it is shown in what direction these carrying members can be perfected and by what changes certain noteworthy defects can be avoided.

In the development of glass bricks, the importance of internal stresses have been underestimated. A special effort should be made to investigate internal stresses in so far as they affect the finished carrying member (beam).

In conclusion, it is emphasized how important it is to over-test glass plates of large dimensions as to resistance against wind, pressure, and other mechanical stresses. In this connection, it is established on the basis of experiment that the usual sizes do not often meet this requirement. In the field of illumination, there are demonstrations of a better utilization of daylight (making use of the zenith light by means of mirrors).

Recent X-Ray Investigations of Glasses, *By Dr. E. Schiebold, Leipzig.*

The famous Nobel prize winner, Professor W. L. Bragg, reported at the 13th Symposium on Glass Technology on the sub-microscopic structure of crystallized silicates studied with the help of the modern X-ray interference method. An important result of these researches is the demonstration that in the silicates, tetrahedral silicon-oxygen groups exist which are united in complex, anion lattices in 1-, 2-, and 3-dimensional chains, in whose vacant spaces the alkali- and other cations are situated.

In contrast to these conclusions of X-ray research in crystalline silicates, the researches—especially by American authors—in the years since 1930 have not brought the expected insight into the structure of the glassy silicates. This applies also to the hypothesis of Randall, Rooksby, and Cooper, according to which the glasses, especially the silica glasses, are formed from highly dispersed crystobalite crystals (of about 15 Å diameter). There are weighty grounds against a general acceptance of this view, on which B. E. Warren, in particular, has reported.

On the other hand, the glasses have hitherto been regarded, mainly on the basis of thorough-going research of G. Tammann and his co-workers, as under-cooled liquids. A direct proof of this hypothesis, by X-rays, was first made possible by the fundamental research on liquids and gases by Debye and Scherrer in 1916. Seljakow, Strutinski, and Krasnikow attempted to apply these methods to glasses as early as 1925. W. H. Zachariasen came to the conclusion in 1932 that in the glassy condition, there exists a heterogeneous structure of tangled silicon-oxygen tetrahedra, in whose vacant spaces the alkali- and other cations find space.

An experimental proof of the hypothesis, however, was first obtained by B. E. Warren somewhat later in 1934-1935, with the help of precise X-ray methods. The result of these important investigations in glasses composed of silica, germania and beryllium fluoride established in the main the pronouncement of Zachariasen. They have led, moreover, to quantitative conclusions which are of fundamental importance to glass research.

Recent researches by Warren and Loring on binary soda-silica glass have reached the interesting conclusion that, with increasing soda content of the glass, the principal interference maximum which is characteristic for silica glass continually pushes out toward a new maximum value that is involved with the position of the sodium-relative to the silicon ion, corresponding to the placement of the former in the vacant spaces of the anion lattice. The theory developed by Warren illuminates these phenomena to a high degree. Quite recently these investigations of B. E. Warren and J. G. Bair have been extended also to the lead oxide-silica glasses.

However interesting the result of the recent X-ray investigations of structure by American authors may be, they must be regarded only as tentative. Warren's advances promote particularly the knowledge of the scattering functions of the single atoms, and are otherwise subject to errors. It seems important, therefore, for research to strike out on a new path which is made possible by the application of the Fourier analysis of X-ray interferences, and permits, with the help of observed intensities, a quantitative estimation of electron pack, and from this the location of the different atoms as a function of their distance from a definite atom regarded as a zero point. The latter part of the discussion deals with this problem.

For the explanation and illustration of the lattice structure of glasses, slides and models were demonstrated.

Fundamental Laws of the Chemical Attack of Glass, *By Dr. W. Geffcken, Jena.*

The phenomena of the chemical attack of glass are admittedly very complex. An approach to the basic principles is made especially difficult by the fact that in most processes, during the measurement, changes that are overlooked, whether in the glass or in the solution employed for the attack, have a strong influence and obscure the simple losses. Therefore, to discover the fundamental laws of the chemical attack on glass, the setting up of a procedure wherein the particular dissolution is limited to the least possible mass, is absolutely necessary.

In measuring spot-sensitiveness, the area of the surface remains practically unchanged and the volume of the attacking liquid per square centimeter of surface can be made very large. If a glass plate is dipped into the acid with uniform speed, a system of interference bands is obtained which, by the application of filtered mercury-vapor light, becomes very visible and may be photographed. The position of the single interference maxima can be estimated with certainty, and is a measure for the thickness of the attacked layer.

It is still more simple to estimate directly the thickness of the destroyed layer with a Haber-Lowe interferometer. By a suitable procedure, the progressive measurements can be made very certain. Thus the dependence of the attack on time is capable of strict mathematical analysis more thoroughly than it was formerly possible.

If x indicates the thickness of glass destroyed, t the time, and K and B are constants, then the time law of acid attack may be definitely expressed by the fraction:

$$\frac{K}{B} \log (Bt+1)B$$

not on the contrary by the parabolic law $x^2=Bt+K$. For the time t=zero, we thereby derive an initial velocity dx:dt=K, which can not be accepted as the operation of a progressive solution.

The relationships during the attack of alkalis are very simple. In this case, no layer of silicic acid remains behind as during an attack by acid and water, and the speed of alteration is constant as time goes on.

Since the initial velocity K is conditioned, not by diffusion, but by chemical reaction, the strong temperature coefficient is of special importance. This, according to the equation, K=A.e—E/RT, corresponds to an actuating energy, e, of about 20 cal.

During an attack by pure water, we must reckon with the effect of adsorbed water molecules, caused by the force of polarization. Here, also, conductivity measurements show agreement with the above logarithmic law.

If K is determined for different acids or alkaline concentrations, we obtain an adsorption isotherm. It must

therefore be accepted, that in addition to the attack by water itself, there is still a second and much more rapid reaction taking place. This is accompanied by an adsorption of ions, and upon the addition of the necessary activating energy, proceeds with the formation of soluble products in which again, the polarization of the neighboring water molecules plays an important role.

The Dependence of Density and Viscosity Upon Temperature in the System Na_2O—SiO_2, *By Dr. G. Hadtkamp and Prof. Dr. K. Endell, Berlin.*

Densities were measured in the viscous range, according to the procedure of W. Hanlein, under melted sodium chloride. In the thinly fluid range, these were calculated from the direct buoyancy of a platinum ball; for the very thinly fluid, high alkali sodium silicate glasses, a new Schwing viscosimeter was developed in which the viscosity could be measured down to 0.2 poises without error, by the dampened swings of a platinum ball.

Density and viscosity fall off steadily with temperature and increased sodium oxide content. Inflection points, indicating with any certainty the existence of compounds in glasses in the fluid condition, could not be found. These results agree with the X-ray studies of the same system by B. E. Warren, whose measurements were confirmed and extended by U. Hofmann. Conclusions were drawn as to the inner structure of fluid glasses.

Changes in the Transmission with Temperature Above and Below the Transformation Point, *By Dr. A. Klemm, Jena.*

When glass is heated to high temperatures, its transparency in the limited spectral range changes. For uncolored glasses the transparency changes, especially in the ultra-violet. The quantitative estimation of transmission at high temperatures offers difficulties. The experimental procedure described offers an accurate measurement of transmission for the ultra-violet and for the visible spectrum up to temperatures above the transformation point.

For uncolored, optical glasses, it was found upon slow heating that the absorption limit lying in the ultra-violet is depressed toward the longer waves with mounting temperature. When the wave length, λe is plotted against the temperature, for equal transmission or extinction e, the single points lie well upon three straight lines, with different slopes. The intersection points of the single straight lines agree very well among themselves, and with the inflexion points of the expansion curve of the same glass obtained with equally slow speed of heating—i.e., with the so-called dissociation point and the transformation point. It follows therefrom, that the temperature coefficient of transmission, or wave length of equal extinction, changes suddenly at the transformation point.

In contrast to other properties such as refraction or density, the transmission appeared to be independent of the thermal history in the uncolored glasses investigated. A well-annealed piece of glass shows, at room temperature, as well as at higher temperatures, the same transmission as a piece from the same melt which has been previously disannealed, and radically changed as to refraction, density and bi-refringence. Many colored glasses showed, on the contrary, a definite dependence of transmission upon thermal history.

From this, a further inference may be drawn: that the variability of the temperature coefficients at the transformation point are not conditioned by the frozen-in, internal (chemical) changes in condition. For these latter do not influence noticeably the transmission of uncolored glasses. To an equal extent, the wave lengths of equal extinction of these glasses show a sudden change of temperature coefficient at the transformation point.

Industrial Research in the Larger Glass Factories, *By Dr. M. Thomas, Berlin-Siemansstadt.*

The program of operating a glass research laboratory in one of the leading German electrical concerns is portrayed. The success of such a laboratory depends essentially upon how far the scientist and the operator cooperate.

The co-operation of the research laboratory with the operating end consists essentially in: (1) The routine observation and study of all essential glass raw materials and correct weighing and mixing of the batch. (2) The continual testing of the usual means of operation, in particular fuel gases: daily overseeing of pyrometery, technical testing of the refractory materials, and checking of their uniformity. (3) Co-operation with the glass melting process, development of the best melting processes for different types of glasses, especially with new glasses; following up defects in glass. (4) Persistent overseeing of the outgoing ware with the closest contact of the research laboratory with all information concerning the reworking of the glass; development of typical testing procedures according to the purpose for which the glass is intended. (5) The tasks which arise from the observance of the factory in the broader view (the statistical analyses of detailed reports leading to the establishment of normal operating values, special tests of the different units of the factory, estimation of the properties of glass at different temperatures, studies on glasses of different kinds, weathering studies, etching studies, investigation of the causes of breakage of glasses, etc.)

New developments group themselves as: (1) Research work leading to the development of glasses or refractory materials with definitely desired properties in close cooperation with the published reports of progress. (2) Introduction of new glasses on a producing scale. (3) Continuous observation of new phenomena in the field of glass by pursuit of the literature published, patents, and experimental work. (4) The conduct of pure research work, first without regard to its practical application, as a debt of the works to science, and for an eventually profiitable application of the results in later years. Work on the constitution of glasses, the transformation points, the chemistry of the colored and opaque glasses, etc.

"Rusting" of the Selenium-Iron Glasses and Its Meaning for Decolorizing by Selenium, *By Dr. A. Dietzel.*

The pure selenium rose color is in practice obtained only in glasses very low in iron oxide. In the presence of an iron oxide content of about 0.01-0.02 per cent Fe_2O_3, a reddish brown coloring substance forms in the temperature range 400-700°C. This is a much more

powerful colorant than selenium alone, and is called iron selenide. It has a typical rusty color.

The depth of color is determined by the existence of a chemical equilibrium between undissociated and dissociated iron selenide. The position of the equilibrium and the velocity with which it will be reached, depends upon the temperature, the concentration of iron and selenium, etc., but especially upon the melting conditions (atmosphere). This is of especial significance for decolorizing with selenium. The more oxidizing the conditions under which the glass is melted, the slower it will change color upon cooling, and the more easily it will arrive at the desired coloring. In a neutral melt, it rapidly changes to a rusty color and, indeed, so quickly that even before the usual annealing, the greater part of the iron selenide has formed. Therefore, no further coloring in the lehr need be feared. In reducing melts, it also becomes rusty quite quickly, but it is not in condition to neutralize the iron color, now largely changed toward blue. Definite statements can be made as to the controlling chemical equilibrium.

Otto Schott's Early Work and Its Significance for Glass Technology, *By G. Keppeler, Hanover.*

The direction of the early activities of Otto Schott was influenced by the old family tradition, by the contact which he had in his youth with glassmaking, and by the broadening of his outlook by studies in chemistry and technology at Aachen and Wurzburg. These influences find definite expression in his first scientific work, which he carried out in Leipzig and Jena for his doctor's degree. This concerned no single limited problem but three various matters—raw materials, melting, and devitrification. Work with these three problems defined Otto Schott's further technical career.

In the field of studies in chemical technology, he saw glassmaking completely in the sense of a chemical process, and demanded economical use of raw materials and complete utilization of by-products. He even regarded the sulphur dioxide, set free during the sulfate melting, although it escaped invisibly through the chimney, as a by-product not without value, whose utilization he sought.

In a patent taken out in 1876, he proposed to introduce lime also as a sulfate (gypsum) into glass, and to prepare a fritted cullet with simultaneous recovery of sulphuric acid in a chamber process. Thus he led the successful development of sulphuric acid recovery from gypsum in connection with the manufacture of cement during the World War. These researches at the same time gave the explanation, which is still the accepted one, of the reactions taking place during the sulfate melting of glasses.

His interests in the direction of inorganic, heavy-chemical industries next found further material, when Schott was employed in a sulphuric works in Haspe in 1876. Thence he went to the founding of a chemical factory near Oviedo in Spain (1877-1878). This period was fruitful, because it gave Schott further experience in the field of factory technique and the building and operation of industrial furnaces.

The third portion of his doctorate, on devitrification, resulted in an important contribution to the clarification of this problem and made definite progress toward the general knowledge of the behavior of glass. It was important for the career of Schott, because, after his return from Spain, he combined the problems of melting and of devitrification as co-ordinate portions of his doctor's work. He occupied himself thoroughly with the question of how one particular inorganic substance dissolves in a molten liquid, and what reactions take place in the melt. (Published under the title, "Introduction to the Knowledge of Inorganic Fusion Compounds", Braunschweig, 1880). These comprehensive studies inevitably led Schott, whose deep interest was all in glass, to attempt to make glasses with new properties by the use of new materials.

A new lithium glass, which he sent for testing in 1880 to Professor Abbe at Jena, contributed an answer to the fundamental problem of glasses of a new sort for the further development of optics. Through this circumstance arose the association between the two men whose later collaboration led to a new era in optical glass melting.

PLATE GLASS PRODUCTION IN JANUARY

An increase in the total production of polished plate glass by member companies of the Plate Glass Manufacturers Association in January over the preceding month and over the same month in 1935 is noted. 17,275,632 square feet were produced in January, 1936, as compared to 16,112,218 square feet in December and 13,365,188 square feet in January, 1935.

O-I INCREASES NET EARNINGS

A recent statement by President William E. Levis points out that the net earnings of the Owens-Illinois Glass Co. and its subsidiaries for 1935 were $7,883,496.31 as compared with $6,496,359.46 for 1934. Earnings last year were equivalent to $6.57 per share compared to $5.41 per share earned the previous year, based on 1,200,000 common shares outstanding in 1934 and 1935. A dividend of $1.25 per share was declared by the Board of Directors payable to shareholders on Feb. 15.

BROOKLYN MUSEUM TO DISPLAY MODERN GLASS AND METHODS OF PRODUCTION

The Brooklyn, N. Y., Institute of Arts and Sciences and the Brooklyn Museum have invited leading American manufacturers and designers of glass to participate in an exhibit of glass. The exhibition will open March 20 and close April 19.

To date items submitted by more than 80 contributors have been selected as representative of the finest examples of industrial art of contemporary design, craftsmanship and quality. The Industrial Art department of the Brooklyn Central Museum seeks to stimulate a recognition of industrial arts equal to that accorded the fine arts, and to imbue the public with a sense of the dignity and high quality of American glass.

Models, photographs and moving pictures will show the technical ingenuity and skill that has made mass production of glass possible. Future trends and uses of glass will be suggested by leading industrial designers.

Air Hygiene Foundation of America, Inc., held its first annual meeting in Pittsburgh last month. The Foundation was formed in 1935 by companies from various manufacturing fields to better dust conditions in industry.

Dr. George V. McCauley sights through a polariscope for flaws in the 200-inch disk for the Mt. Wilson Observatory.

STATUS OF LIME IN CONTAINER BATCHES

SEVERAL years ago both theoretical and practical discussions on the subject of the proper type of lime to use for the manufacture of flint glass containers were quite frequent. The net result of these discussions was that everyone continued to use the same type of lime as before, despite the outcome of the discussion. The last few years have brought a change in this attitude, however, and a comparison of the glass batches in use today with those in use several years ago will show a marked change in ideas on the subject.

Turning back to the old discussions on why the glass manufacturer should or should not use raw lime, burnt lime, high calcium lime or dolomitic lime in his batch we find the following "pros" and "cons."

In the case of burnt lime versus raw lime, we find raw lime favored because:

1. The price of raw lime is lower than burnt lime;
2. The gas given off by the decomposition of the raw lime materially assists in the formation of seed and cord-free glass;
3. Raw lime does not pick up moisture and carbon dioxide during storage;
4. As raw lime is more or less granular, it is easier and cleaner to handle than burnt lime which is in the form of a fine powder.

Those in favor of burnt lime claim as follows:

1. Burnt lime is purer in composition because it is manufactured from selected pieces of raw lime;
2. The iron present in burnt lime exists in the ferric state (due to the burning process) and therefore imparts less color to the glass;
3. In grinding limestone there is a possibility of metallic iron contamination and, as metallic iron appears to have an excessive coloring action, its presence in an excessive amount in raw lime is a disadvantage;
4. Due to the fact that no gas is given off it is possible to pull a tank harder without running into seedy glass when burnt lime is used in the batch.

In the case of high calcium lime versus dolomitic lime, the latter was preferred, because of the tendency of high calcium glasses to devitrify and to their setting rate which was too rapid for the forming machines in use then.

At present these arguments are no longer important or true. Investigations conducted in the past few years on ways and means of speeding up machines and production, increasing tank pull and in some cases increasing the durability of the glass, are partly responsible for the change in the "best type of lime" attitude.

We find that today lime is being introduced into the batch in the form of mixtures such as raw lime plus burnt lime, dolomitic lime plus high calcium lime or combinations of the four instead of unmixed, as in the older batch formulae.

The reasons for the use of such mixtures is that the various types of lime mentioned possess different actions and give special properties to the melt or the finished glass. Thus, a batch meeting certain specifications can be supplied more easily by utilizing a mixture of the various lime materials.

For instance, it is known that, with other conditions constant, the batch should have a certain melting loss if seed-free homogeneous glass is to be made. If the durability of a glass made from a burnt lime batch is increased through the addition of feldspar, the melting loss is decreased as the feldspar is a non-gas former.

In addition, the viscosity of the glass at the melting temperature may increase due to the addition of the alumina from the feldspar. If the feldspar increase is great, the melting loss may decrease and the viscosity increase to such an extent that it becomes difficult to produce seed and cord-free glass. The replacement of part of the burnt lime by sufficient raw lime to bring the melting loss up to, and possibly greater than, the previous melting loss (to take care of the viscosity increase) may materially assist in correcting the trouble.

In cases where raw lime is used and sufficient gas is formed but the tank pull is to be radically increased, there is the danger of forming seedy glass. Reversing the procedure given in the example above is the solution to this problem. Part of the raw lime is replaced by burnt lime so as to lower the amount of gas formed.

Present day methods of forming glass containers demand a glass with a more rapid setting rate so that advantage may be taken of the increased machine speeds. In plants where the use of dolomitic lime has been the practice, mixtures of dolomitic lime and high calcium lime are now used in order to meet this requirement. Practical experience has shown that a glass containing lime in the dolomitic ratio, 58 per cent CaO and 42 per cent MgO can be improved by changing the lime ratio to approximately 75 per cent CaO and 25 per cent MgO. Glass containing lime in the latter ratio sets quicker, thereby utilizing the full speed of the machine, has improved working qualities and less tendency to check than a glass containing lime all as CaO.

In addition to viscosity improvements, such a glass also shows greater durability and resistance to weathering than a glass containing dolomitic lime only. This is because the effect of CaO on increasing durability and weathering resistance is greater in magnitude than MgO. A change in the CaO . MgO ratio, whereby the CaO is increased, is therefore a decided advantage.

As far as devitrification is concerned, an increase in the proportion of CaO in the glass no longer implies the danger of "dog" formation. Modern glass container batches contain so many new ingredients acting to retard devitrification, that this fault is no longer a problem except in batch segregation troubles.

Turning back once again to the use of raw lime, the old argument of its effect on the color of flint glass has been settled largely through the activities of the lime producer. Improved methods of quarrying, selection, washing, technical control and other operations have played a large part in assisting the lime producer to supply the glass industry with a stone of any desired grain size and iron content, consistently and promptly.

The Department of Ceramic Engineering of the University of Illinois will hold a symposium on enameling at Urbana on May 9. Subjects of current interest to enamelers will be discussed.

SANDWICH GLASS

By ALEXANDER SILVERMAN[1]
Head of the Department of Chemistry, University of Pittsburgh

This is the second of a series of articles on Sandwich Glass written by Professor Silverman for The GLASS INDUSTRY. *The series is unique in that the author has had access to original sources never before available. Much, if not all of the information, including batch formulae, is given for the first time. The first article in the February issue, discussed crystal glass. This month the subject is opal and alabaster glass in which, Professor Silverman, himself, has been engaged in extensive research for the past thirty years and longer. Next month and succeeding issues will deal with the manufacture of colored glasses, including certain special treatments peculiar to Sandwich Glass.—The Editor.*

THE records of batches employed in the Sandwich factory on Cape Cod indicate a knowledge of a considerable variety of opal and alabaster glasses. The batch book of the late William E. Kern, who was a recognized glass expert in his day and for years general superintendent of the Sandwich factory, contains numerous opal and alabaster batches. The batches are recorded exactly as given in his book, but the numbers refer to the author's records.

No. 5. Doherty Cryolite Batch:

Sand	1500 lb.
Lead	225 lb.
Soda ash	300 lb.
Cryolite	200 lb.
Nitre	100 lb.
Siftings	1000 lb.
Manganese	2 lb.

The name of John Doherty appears on the document which was presented to George L. Fessenden on Feb. 22, 1860, with a magnificent silver service. In some of Mr. Kern's later batches there is a reference to a John Daugherty. Whether this is the same individual or another is uncertain. No name of the latter spelling is included in the document. Batch No. 5 utilizes cryolite alone for producing opacity. It is interesting to know that "siftings" were employed instead of coarse cullet. It is highly desirable to crush cullet and add a weighted quantity of a definite mesh to a batch before mixing. Many modern manufacturers fail to realize the importance of such procedure.

No. 6. Dithridge Opal:

Sand	1000 lb.
Nitre	75 lb.
Lead	260 lb.
Potash	150 lb.
Soda ash	140 lb.
Fluorspar	170 lb.
Feldspar	170 lb.
Cryolite	20 lb.
Oxide antimony	3 lb.
Borax	5 lb.
Manganese	1½ to 3 lb.

The name Dithridge does not appear in the document mentioned. Perhaps he was Edward Dithridge who, in 1857, assumed ownership of the Fort Pitt Glass Co., in Pittsburgh. Batch No. 6 utilizes fluorspar, feldspar, and cryolite, and includes antimony, probably the trioxide, as well as borax. Lead means red lead.

No. 13 A. Opaline Glass:

Sand	140 lb.
Soda	33 lb.
Opaline	80 lb.

B. John Daugherty Opaline Batch:

Sand	130 lb.
Soda	23 lb.
Potash	15 lb.
Opaline	100 lb.

The term "opaline" is used in two ways in Kern's records: first, as an opacifying agent; and second, to indicate the type of opal glass. In these batches it refers to the opacifying agent, for nothing is indicated in the batch except sand, alkali, carbonate, and opaline. A preparation sold under the trade name "Opaline" was still in use in 1914 and had the following analysis:

Silica	47.22 per cent
Fluorine	26.75 per cent
Calcium	7.77 per cent
Sodium	7.30 per cent
Alumina	6.21 per cent
Iron	0.62 per cent
Moisture	0.45 per cent
Oxygen (by difference)	3.68 per cent

This is obviously a mixture of sand, fluorspar, and cryolite.

No. 15. White Batch, Harrup:

Sand	1000 lb.
Litharge	300 lb.
Potash	200 lb.
Feldspar	230 lb.
Fluorspar	230 lb.
Nitrate soda	75 lb.
Bone ash	20 lb.
Bicarbonate soda	20 lb.
Oxide zinc	4 lb.
Manganese	2 lb.

Here bone ash is utilized with fluorspar and feldspar, and a small amount of zinc oxide is introduced. Harrup's name occurs frequently in Kern's batch book.

No. 19 A. Opal (Kern) for coating:

Sand	200 lb.
Lead	155 lb.
Ash	62 lb.
Saltpeter	35 lb.
Borax	1½ lb.
Arsenic	30 lb.
Manganese	1 lb.

B. Opal for coating:

Sand	105 lb.
Lead	78 lb.
Ash	28 lb.
Nitre	17 lb.
Bone	½ lb.
Borax	8 oz.
Arsenic	14 lb.
Manganese	12 oz.

[1] Contribution No. 308 from the Department of Chemistry, University of Pittsburgh.

The first is evidently a batch developed by Mr. Kern himself. Note that A depends on arsenic trioxide as an opacifier and that B also utilizes it, together with a small amount of bone ash. The latter batch was used for making opal-cased tubing.

No. 20. Lloyd's White:

Sand	1000 lb.
Lead	360 lb.
Nitrate soda	100 lb.
Potash	125 lb.
Bicarb. soda	160 lb.
Fluorspar	160 lb.
Feldspar	160 lb.
Manganese	1½ lb.

"James D. Lloyd was both a glass expert and a book keeper. In fact, Mr. Lloyd was known as a color evolutionist."[2]

No. 21. Opalescent Batch:

Flint batch with saltpeter	750 lb.
Bone ash	46 lb.
Arsenic	15 lb.
Cullet	250 lb.

"Yellow nitrate of silver dissolved in clear water. Shake salt over it. Wash again, dry and pulverize in a mortar 3 oz. to 100 white batch. You can put in a pot as plain and it will be all right."

This is the first batch in which the color depends largely on bone ash, coupled with a considerable amount of arsenic trioxide. The author has never heard of yellow nitrate of silver. The silver chloride formed probably produced a modified type of opalescence.

No. 27. German formula for shades and pressed:

Opaline	80 lb.
{ Soda	33 lb.
{ Sand	141 lb.
{ Potash	8 lb.
{ Sand	136 lb.

The sand-soda combination was probably used for blowing lamp shades and the sand-potash combination for pressing.

No. 28 A. Opaline Batch:

Sand	100 lb.
Soda	30 lb.
Feldspar	10 lb.
Fluorspar	6 lb.
Arsenic	¼ lb.
Manganese	¼ lb.
Nitre	5 lb.

B. For small blown ware and pressed goods:

Sand	100 lb.
Opaline	30 lb.
Soda	26 lb.
Nitrate	5 lb.
Feldspar	12 lb.
Fluorspar	10 lb.
Arsenic	¼ lb.
Manganese	¼ lb.

"If not white enough add 2 lbs. more opaline."

No. 28 A is a batch marked "Opaline" for color, for opaline is not used as an opacifying agent. The modern manufacturer will appreciate the title of B especially as it applies to small pressed ware, for he realizes the difficulty encountered with batches for large pressed objects due to settle mark, silver streaks, cords, etc.

Left, reproduction of document giving names of donors of a silver service to George L. Fessenden.

No. 35. Daugherty's Opaline Batch:

Sand	100 lb.
Nitre	5 lb.
Fluorspar	8 lb.
Feldspar	12 lb.
Soda ash	26 lb.
Opaline	32 lb.

"If this does not make it white enough, add a few lbs. of feldspar, fluorspar, or opaline."

This batch is the last of Kern's opal batches.

GEORGE L. FESSENDEN'S BATCHES (Part I)

MENTION was made in the first article regarding the larger number of crystal batches recorded by Mr. Fessenden and the greater care displayed in recording these. This is also true for opal and alabaster records.

No. 1. Best Opal:

Sand	1000 lb.
Red lead	360 lb.
Bicarbonate of soda	110 lb.
Pearl ashes	115 lb.
Nitrate of potash	60 lb.
Fluorspar	160 lb.
Feldspar	160 lb.
Manganese	1 lb. 8 oz.
Add for shades bicarb. soda	10 lb.

It is not clear why 10 pounds of sodium bicarbonate should have been added to the batch for blowing shades.

No. 3. Common Opal for Pedestals:

Flint black	600 lb.
Flint batch	100 lb.
Fluorspar	75 lb.
Feldspar	75 lb.
Manganese	3 lb.

Pedestals were manufactured extensively, both pressed and blown, as standards for oil lamps. The term "flint black" probably refers to a crystal glass in which nickel oxide was used as a decolorizer. Coarse cullet of this type has a rather dark appearance.

No. 5. Alabaster White:

Sand	240 lb.
Pearl ashes	100 lb.
Baryta pure precipitated carbonate	4 lb.
Plaster of Paris	6 lb.
Fluorspar	14 lb.
Arsenic	2 lb.

In this batch plaster of Paris (calcium sulfate) is responsible for the alabaster effect. It is interesting to note that this alabaster batch is one of a variety for which the art of manufacture was lost for a time. In an earlier article[3] the author traces the history back to the seventeenth century and cites a batch[4] in which sodium phosphate and calcined alum were added to a crystal batch. It is not likely that the sulfates in the alum were completely destroyed through calcining. The alabaster effect may be produced by adding a salt, such as a chloride or a sulfate, to an opal batch. Opalescence is due to a colloidal suspension of particles. Most colloidal particles carry an electrical charge, probably due to adsorbed ions. Salts such as the chlorides and sulfates ionize in molten glass, though to a smaller extent than they do in aqueous media[5]. Ions carrying a charge opposite to that of the colloidal particles precipitate these, so that larger aggregates are formed[6]. and white light is transmitted instead of fiery or opalescent light. When wood ashes and Le Blanc soda ash were employed in glass making, these contained chlorides and sulfates as impurities[7] and probably produced alabaster effects before chlorides and sulfates were deliberately introduced into batches.

It was the author's good fortune, while trying to produce an alabaster glass (1902-1904), to introduce salt as a stirring agent because of its fairly high vapor tension. Little was known of the effects of salts on opal glasses, but it so happened that the salt produced an alabaster glass and revived the art which had been lost through the advent of pure alkali carbonates. Manufacturers, also uninformed regarding the function of dissolved salts and the earlier history of alabaster glass manufacture, obtained patents covering their processes[8]. The revival of alabaster glass manufacture was important in the day of the Edison carbon-filament lamp, for the light emitted was rich in orange, and opal glasses enhanced this effect, while alabaster glasses transmitted the light as emitted by the carbon filament and even seemed to whiten it.

Fessenden batch No. 5 is interesting from another angle. The author in furthering his research on this type found, about 1908, that the presence of barium compounds instead of calcium compounds produced superior alabaster glasses. The amount employed was very close to that which is indicated in the batch cited. Recently, the use of barium compounds has been covered in a number of patents. Some of these are again a revival of old practice[9].

No. 13. White Enamel for Casing:

Sand	150 lb.
Minium	150 lb.
Potasse	45 lb.
Bone dust	22 lb. 8 oz.
Oxide of tin	6 lb.
Arsenic	6 lb.
Tin and lead	9 lb.

"Tin and lead consists of Tin and Lead in the proportion of two parts of Tin to one part of Lead prepared in your Lead oven in the form of Putty."

Here we have the first reference to oxide of tin, undoubtedly stannic oxide, as an opacifying agent in Sandwich glass. It had been used in Europe. The idea of preparing a mixture of the oxides of tin and lead in the ovens at Sandwich seems novel. The white enamels were probably used for casing crystal as well as ruby, green, and other colors which were manufactured on Cape Cod.

No. 14. Another White Enamel for casing which I prefer:

Sand	150 lb.
Minium	150 lb.
Potasse	45 lb.
Bone Dust	22 lb.
Oxide of tin	3 lb.
Arsenic	6 lb.
Tin and lead	12 lb.

"This is rather a cheaper formula and is less likely to become lumpy or knotty as the tin fluxes more perfectly when in combination with the lead."

No. 41. French Alabaster:

Sand	600 lb.
Lead	40 lb.
Ash	250 lb.
Salt petre	30 lb.
Plaster	26 lb.
Lime	10 lb.
Arsenic	10 lb.

This is the first alabaster glass which depends on arsenic trioxide and plaster of Paris alone.

No. 42. Creolite Opal:

Sand	150 lb.
Soda ash	30 lb.
Creolite	25 lb.
Lime	6 lb.
Nitrate soda	6 lb.

Mr. Fessenden probably means "cryolite."

No. 45. Alabaster:

Sand	120 lb.
Lead	6 lb.
Ash	50 lb.
Salt petre	2 lb.
Lime	8 lb.
Fluorspar	2½ lb.

Either something was omitted from this batch or the alabaster color was due to a devitrification effect. Some glasses, as the result of prolonged heating or high cullet content, will devitrify and produce such effects.

No. 46. Enamel

Sand	80 lb.
Lead	80 lb.
Salt petre	13 lb.
Ash	10 lb.
Putty powder	8 lb.
Arsenic	7 lb.
Bones	2 lb.

Putty powder is gray stannic oxide containing impurities. It is also known as polishing powder, tin stone, and tin ash.

No. 52. White Opaque:

Sand	200 lb.
Feldspar	150 lb.
Soda ash	80 lb.
Salt petre	20 lb.
Bones	10 lb.
Fluorspar	10 lb.
Lime	30 lb.
Arsenic	1 lb.

No. 53. Soft Alabaster:

Sand	100 lb.
Ash	70 lb.
Lead	30 lb.
Bones	12 lb.
Arsenic	10 lb.

Here the alabaster effect probably depended on impurities in the ash.

No. 57. Enamel:

Sand	200 lb.
Lead	250 lb.
Plaster of Paris	40 lb.
Arsenic	50 lb.
Borax	10 lb.
Salt petre	80 lb.
Tin	25 lb.

This is the first combination of plaster of Paris, arsenic trioxide, and stannic oxide for opacifying.

No. 60. Opal:

Sand	120 lb.
Ash	60 lb.
Lead	30 lb.
Salt petre	10 lb.
Bones	20 lb.
Arsenic	15 lb.
Com. salt	10 lb.

This is the first mention of common salt. The glass was probably an alabaster and not an opal glass.

George L. Fessenden's Batches (Part II)

BETWEEN Part I and Part II in the Fessenden volume one finds numerous notes. A few, pertinent to the immediate discussion, follow:—

"Oxide of tin used in enamels and in combination with gold for making ruby. It should be very white and fine. It is very useful in aiding the opacity of enamels."

"Borax. This is useful as a flux and it also gives brilliancy and whiteness to the metal. There is always a certain portion of soda mixed by the refiners with the boracic acid."

"Phosphate of soda helps to whiten glass but is very expensive."

No. 1. Old English:

Sand	124 lb.
Red lead	84 lb.
Potash	28 lb.
Salt petre	28 lb.
Bone dust	10 lb.
Arsenic	3 lb.

No. 3. Opal French new system, 2nd quality:

Sand	250 lb.
Red Lead	80 lb.
Potash	20 lb.
Bicarbonate of soda	30 lb.
Nitrate of soda	10 lb.
Feldspar	40 lb.
Fluorspar	40 lb.
Manganese pure	6 oz.
Blue manganese	6 oz.
At bottom of pot manganese pure	2 oz.

Here the blue manganese, which was mentioned as a variety of pyrolusite under crystal batches, is used again together with pure manganese. Note that a small amount of manganese is thrown into the bottom of the pot before the batch is introduced. There is a tendency of some opal glasses to burn out or lose color when one nears the bottom of the pot. Perhaps the oxidizing agent was placed in the bottom of the pot to prevent this, although it is doubtful whether it could have remained stable sufficiently long for the purpose.

No. 4. Opal French new system, Cheap:

Sand	250 lb.
Red lead	80 lb.
Bicarbonate of soda	60 lb.
Nitrate of soda	10 lb.
Fluorspar	40 lb.
Feldspar	40 lb.
Manganese pure	6 oz.
Blue manganese	8 oz.
At bottom of pot manganese pure	4 oz.

Here the cost of the batch is cut down by substituting sodium bicarbonate for the potassium carbonate employed in No. 3.

No. 5. Cheap Opal for Reflectors:

Sand	250 lb.
Red lead	60 lb.
Bicarbonate of soda	90 lb.
Nitrate of soda	10 lb.
Feldspar	40 lb.
Fluorspar	40 lb.
Manganese pure	8 oz.
Blue manganese	8 oz.
Manganese pure at bottom of pot	4 oz.

This is even less expensive than No. 4 because of the reduction in red lead content. The term "reflectors" probably means lamp shades for oil lamps.

(*Continued on page* 99)

EQUIPMENT AND SUPPLIES

CATALOGS RECEIVED

Pyro—The Simplified Optical Pyrometer. No. 70. Pyrometer Instrument Co., New York. Describes a self-contained, direct reading precision instrument. Fully illustrated to show features of the instrument and requirements for its maintenance.

Anything in Glass. Butterworth Bros. Ltd., Manchester, England. Interestingly illustrated booklet showing industrial glass, glass tubing, rods and canes, lighting and surgical glass. A useful index to contents is furnished.

American Dustube Collector. Folder No. 222. American Foundry Equipment Co., Mishawaka, Ind. Illustrates the features of the American Dustube design and lists many of the materials which can be collected by this system.

The Spectrum Measuring Microscope. Bausch & Lomb Optical Co., Rochester, N. Y. Introduces their new spectrum measuring microscope which has a 5 micron accuracy anywhere over a 10-inch spectrogram.

MULTI-ROTARY TABLE TO CLEAN CASTINGS, FORGINGS

The American Foundry Equipment Co., Mishawaka, Ind., has recently introduced its Wheelabrator multi-rotary table, which consists of a number of independent tables. The number and diameter of these tables may be varied to suit particular needs.

A guide under the center of each table runs in a track in a straight line under the Wheelabrator for about six feet. This directs the table under the blast to obtain the full effective blasting range of the abrasive as it leaves the wheel. The flat vertical side of the table contacts a moving belt revolving the tables as they pass under the blast. The speed of this belt is variable so that the speed of turning of the tables may also be varied.

The company recommends this instrument for certain types of castings, forgings and stamped metal parts that might be injured or scratched if they were subject to the tumbling types of abrasive machinery. For further details, ask American Foundry for folder number 33.

SPECTRUM MEASURING MICROSCOPE

A new spectrum measuring microscope has just been designed in the laboratories of Bausch & Lomb, Rochester, N. Y., for the rapid and precise measurement of the linear intervals between spectrum lines on the photographic plate. It is applicable to a wide range of work, such as the examination of shrinkage and expansion of photographic films in aerial mapping, measurement of thermal expansion of metals and the elongation of test specimens in creep tests under load.

The photographic plates or other object to be measured is carried in a horizontal position upon a sliding table to which a glass scale is rigidly attached. The object is in constant fixed relation with a constant measuring device. The scale is 250.0 mm long, ruled directly upon a thick glass plate and is read by transmitted light. The magnified image of scale and vernier is projected by a microscope objective upon a horizontal ground glass screen underneath the eyepiece of the reading microscope.

NEW PRESSING MACHINE ANNOUNCED BY LYNCH

Lynch Corporation, Anderson, Indiana, is offering a new type of pressing machine, said to embody several entirely new features in a single machine. It has a wide range of applications and may be used for articles varying in size from a small whiskey glass up to a meat platter. It may be utilized for the production of pressed ware in block, or open and shut, molds and is adaptable for the production of tumblers, jellies, tableware and many other articles. The machine will accommodate 12 molds. For further details on the new press, which is known as Model MPLS, ask Lynch for folder No. 51.

Clark Trutractor Co., Battle Creek, Mich., manufacturers of gas-powered industrial trucks, tructiers and tractors, announced that Harry B. Clapp has joined its staff as transportation engineer. Mr. Clapp's services will be at the disposal of manufacturers seeking methods and means of lowering material and freight-handling costs.

EARLY BACK AT AMSCO PITTSBURGH OFFICE

Joseph Early, who has been in charge of constructing the new factory for the plant of the Obear-Nester Glass Co. in East St. Louis, has completed the assignment and is now back in the offices of the Amsler-Morton Co. in Pittsburgh.

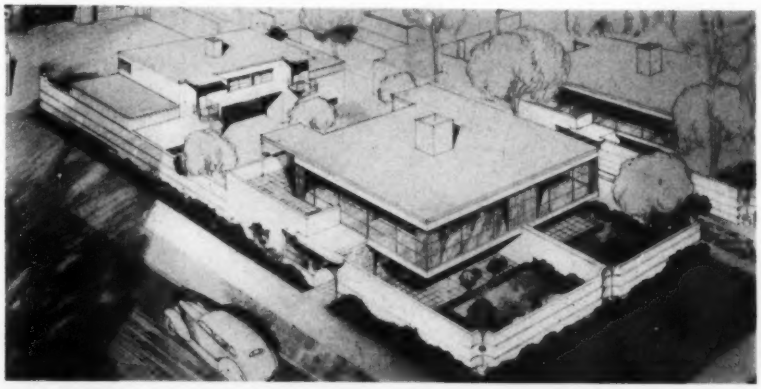
Johns-Manville Sales Corporation, according to T. K. Mial, vice-president, has appointed George Dandrow manager of the New York district office of the power products and industrial development. Mr. Dandrow will be located at 22 East 40th St., New York.

Harnischfeger Corporation, Milwaukee, has appointed Charles R. Surface sales manager of the P & H electric motor sales division. Mr. Surface was formerly with the Sprague Electric Works of the General Electric Co. and was later in charge of the building equipment department of Westinghouse. Mr. Surface will be located in Milwaukee.

FURNITURE SIZE AIR CONDITIONER

A furniture-like device recently put on the market by Miller Conditionair, Inc., Los Angeles, is said to serve as an air-conditioning factory in itself. This instrument is convenient for offices, stores, hospitals or homes. It weighs only 175 pounds and takes up very little room, being 13 inches wide, 12½ inches deep and 34 inches high, as well as being a reasonably attractive piece of furniture.

Each Miller Conditionair unit heats 8,000 cubic feet and cools 5,000 cubic feet. It circulates approximately 595 cubic feet of fresh air every minute and uses only 16 gallons of water per hour. The machine is said to insure fresh clean air at all times. Illustrated below is the new type of all-glass house in which this equipment will be utilized.



A new type of home in California equipped with the Miller Conditionair.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.		5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	Po. or Gr. / Cry.	.25 / .25½
Aluminum hydrate (A1 $(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14½
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	.12¾	.13¾
Antimony oxide (Sb_2O_3)	lb.	...	.13¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	1.00-1.10
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.29
In 10 lb. tins	lb.	...	1.39
Copper oxide Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15
Black prepared	lb.	..	.22
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09¼
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.07	...
In 5 Ton lots	lb.	...	.075
Less than 5 Tons	lb.	...	.08

		Carlots	Less Carlots
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.06	...
In 5 Ton lots	lb.	...	.065
Less than 5 Tons	lb.	...	.07
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide In Paper bags	ton	50.00	52.50-55.00
In Burlap bags	ton	51.50	54.00-56.50
In Casks	ton	53.00	55.50-58.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.09
Powdered	lb.	...	.09¼
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅛
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.29
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17½-.18¼
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08¾
Sodium fluosilicate (Na_2SiF_6)	lb.	.05½	.06
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.36½
Tin oxide (SnO_2) in bbls.	lb.	...	.51
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.05	.05¼
White Seal, 150 lb. bbls.	lb.	.06¼	.07
Green Seal bags	lb.	.06	.06¼
Red Seal, bags	lb.	.05½	.05¾
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05

SANDWICH GLASS

(*Continued from page 96*)

No. 13. Alabaster White (pate de Riz):

Sand	180 lb.
Potash	75 lb.
Baryta carbonate pure precip.	3 lb.
Plaster of Paris	5 lb.
Fluorspar	10 lb.
Manganese	12 oz.
Arsenic	1 lb. 8 oz.

Here is the first reference to "pate de Riz" or rice paste, which this type of glass resembles. It is another example of the utilization of barium carbonate and plaster of Paris.

No. 25. Casing Enamel:

Sand	50 lb.
Red lead	50 lb.
Potash	15 lb.
Bone dust	7 lb. 8 oz.
Oxide of tin	2 lb.
Arsenic	2 lb.
Putty powder	3 lb.

It is not clear why both oxide of tin and putty powder should be employed unless the Sandwich glass makers did not know that the latter is also stannic oxide. This glass was used for casing the flint glass which follows:

No. 22. Casing Flint:

Sand	300 lb.
Red lead	200 lb.
Potash	80 lb.
Salt petre (nitrate of potash)	10 lb.
Arsenic	2 oz.
Manganese	4 oz.

No. 26. Another Enamel:

Sand	90 lb.
Red lead	90 lb.
Potash	25 lb.
Nitrate of potash	3 lb.
Fluorspar	14 lb.
Feldspar	14 lb.

No. 27. Casing Opal:

Sand	150 lb.
Red lead	100 lb.
Potash	30 lb.
Nitrate of potash	15 lb.
Bone dust	15 lb.
Putty powder	5 lb.
Oxide of tin	3 lb.
Arsenic	5 lb.

From the first installment on Sandwich glass it was evident that the glass makers in this factory had a remarkable knowledge of crystal glass for their time. The borosilicate glasses were not yet known, but with this exception and the use of compounds of the rarer elements, practically every type was made at Sandwich. We are similarly impressed with their knowledge of opal and alabaster glasses. Of course, the borosilicate opals and the newer zinc-aluminum alabasters had not yet come into being. The only one of the old alabaster glasses which seems to be missing in the Sandwich records is that which utilized Federweiss, a natural magnesium silicate. This was employed in Germany.

The ensuing installments will cover the manufacture of colored glasses and such special treatment of glass as was applied in Sandwich.

[3] Frank W. Chipman, "The Romance of Sandwich Glass", Sandwich, Mass. (1932) p. 56.
[3] Alexander Silverman, "Alabaster Glass: History and Composition", J. Am. Ceram. S., **1**, 247 (1918).
[4] Deming Jarves, "Reminiscences of Glass Making", New York (1865), p. 105.
[5] Willard J. Sutton and Alexander Silverman, "The Electrical Conductivity of Sodium Chloride in Molten Glass", J. Am. Ceram. S. 7, 86 (1924).
[6] Alexander Silverman, "Colloids in Glass", J. Am. Ceram. S., 7, 795 (1924).
[7] Alexander Silverman, "The Importance of Analysis in Purchasing Raw materials for the Glass Industry", J. Am. Ceram. S., **3**, 26 (1920).
[8] George A. Macbeth, U. S. Pat. 1,097,600 (May 11, 1914); U. S. Pat. 13,766 (revised July 7, 1914); Harry A. Schnelbach, U. S. Pat. 1,143,788 (June 22, 1915); Elias L. Elliott, U. S. Pat. 1,192,048 (July 25, 1915); Joseph J. Miller, U. S. Pat. 1,245,487 (November 6, 1917); James O. Handy, U. S. Pat. 1,287,005 (December 10, 1918).
[9] Alexander Silverman, "The Use of Barium Compounds in Glass," J. Soc. Chem. Ind., **34**, 399 (1915).

GATHERINGS OF BRITISH GLASSMEN

At the London section of the British Society of Glass Technology on Feb. 5, Graham Cunningham spoke on simplified construction for scientific apparatus. Mr. Cunningham advocated utilizing ground glass joints of standard dimensions, which are completely interchangeable.

The March meeting of the Society will be featured by a visit to the Osram-G. E. C. Glass Works, North Wembley. At this time, E. Venis will speak on "Glassware Finishing Machinery with Special Reference to Table Ware."

The executive committee of the National Association of Coin-Operated Machine Manufacturers states that the orders for three to four million feet of sheet glass, placed by this industry in 1934 and 1935, must be duplicated with additions during the next 12 to 18 months. During the past two years, some 450,000 of these "ten-ball" games have been sold. Because of wearing out or obsolescence, they must be replaced.

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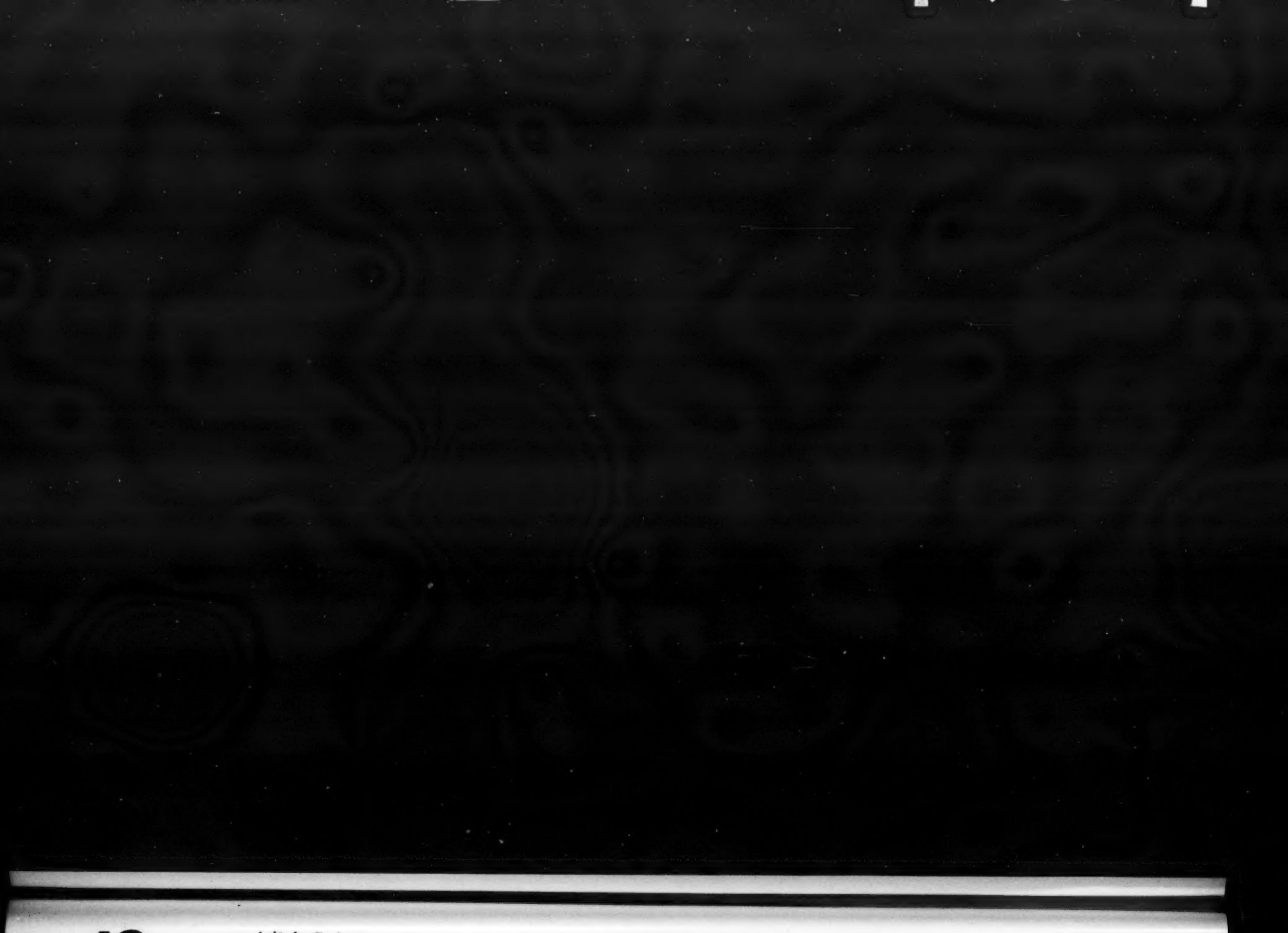
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